JOURNAL OF THE A·I·E·E·

JULY 1929

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PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MEETINGS

of the

American Institute of Electrical Engineers

PACIFIC COAST CONVENTION, Santa Monica, Calif., September 3-6, 1929

REGIONAL MEETING, Great Lakes District No. 5, Chicago, Illinois, December 2-4, 1929

MEETINGS OF OTHER SOCIETIES

National Electric Light Association.

Rocky Mountain Division, Hotel Colorado, Glenwood Springs, Colo., Sept. 9-11 (O. A. Weller, Public Service Co. of Colorado, Denver)

New England Division, Hotel Griswold, New London, Connecticut, Sept. 9-12 (Miss O. A. Bursiel, 20 Providence St., Boston)

Illuminating Engineering Society, Bellevue-Stratford, Philadelphia, Sept. 24-27 (A. B. Oday, 29 West 39th St., New York, N. Y.)

American Electric Railway Association, Atlantic City, Sept. 28-30 (J. W. Welsh, 292 Madison Avenue, New York, N. Y.)

JOURNAL

OF THE

American Institute of Electrical Engineers

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

PUBLICATION COMMITTEE
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Changes of advertising copy should reach Institute headquarters by the 15th day of the month for the issue of the following month.
Subscription: $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines, $10.50 to Canada, Central America, South America, Haiti, Spain and Colonies, and $11.00 to all other countries.
Single copies $1.00.

Entered as matter of the second class at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress, March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

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Institute and Related Activities

A REQUEST FOR CHANGE OF ADDRESS must be received at Institute headquarters at least ten days before the date of issue with which it is to take effect. Duplicate copies cannot be sent without charge to replace those issues undelivered through failure to send such advance notice. With your new address, be sure to mention the old one, indicating also any changes in business connections.

American Institute of Electrical Engineers

—*Some Activities and Services Open to Members*—

The Pacific Coast Conventions as their name implies are always held in the Pacific Coast States or British Columbia, and were inaugurated for the benefit of Western members who by reason of their location could not conveniently attend the conventions held in the eastern part of the country. The engineering problems encountered in the West have also been different to some extent from these in the East owing to the very long-distance high-voltage transmission systems which are characteristic of the Pacific Coast region. The programs of these conventions cover all phases of electrical engineering but accentuate those features which are of peculiar interest to western engineers. Social and entertainment features are always included, as well as inspection trips of special interest to visitors from a distance.

Attendance at Conventions.—Taking part in the Institute conventions is one of the most useful and helpful activities which membership in the Institute affords. The advantages offered lie in two distinct channels, technical information and personal contacts. The papers presented are largely upon current problems and new developments, and the educational advantages of hearing and taking part in the discussion of these subjects in an open forum cannot but broaden the vision and augment the general knowledge of those who participate. Equally advantageous is the opportunity which conventions afford to extend professional acquaintances and to gain the inspiration which grows out of intimate contact with the leaders in electrical engineering. These conventions draw an attendance of 1000 to 2000 people and constitute milestones in the development of the electrical art.

Employment Service.—The employment service is a joint activity administered by the Civil, Mining, Mechanical, and Electrical Engineering societies and is available to the membership of these societies. Branches of this Department are located in Chicago and San Francisco, the main office being located at the societies headquarters in New York. The service is designed to be mutually helpful to engineers seeking employment, and concerns desiring to secure the services of engineers. This department is financed by contributions from the societies maintaining it and from beneficiaries of the service. Further details will be furnished on request to the Managers of the Employment Service at the main or branch offices, addresses of which will be found elsewhere in this issue.

Presentation of Papers.—An important activity of the Institute is the preparation and presentation of papers before meetings of the Institute. Opportunity is offered for any member to present a paper of general interest to engineers at an Institute meeting, or of having shorter contributions published in the JOURNAL without verbal presentation. In preparing a paper for presentation at a meeting, the first step should be to notify the Meetings and Papers Committee about it so that it may be tentatively scheduled. Programs for the meetings are formulated several months in advance, and unless it is known well in advance that a paper is forthcoming, it may be subject to many months delay before it can be assigned to a definite meeting program. Immediately upon notification, the author will receive a pamphlet entitled "Suggestions to Authors" which gives in brief form instructions in regard to Institute requirements in the preparation of manuscripts and illustrations. This pamphlet contains many helpful suggestions and its use may avoid much loss of time in making changes to meet Institute requirements.

Manuscripts should be in triplicate and should be submitted at least three months in advance of the date of the meeting for which they are intended. These manuscripts are submitted first to the members of the technical committee covering the subject of the paper, and if approved will next go to the Meetings and Papers Committee for final disposal. After final acceptance, the paper goes to the Editorial department for printing which requires usually from two to three weeks. Advance copies are desired about ten days prior to the meeting in order to distribute the paper to members desiring to discuss it. Considering the routine through which all papers must pass, the advantage of prompt notification and early submission of manuscripts will be apparent.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

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Institute Progress

THE 1929 Summer Convention has now passed into history. It has marked another milestone in the progress of our organization. There were presented valuable and interesting papers and committee reports, all of great importance in the onward march of the electrical industry.

In a consideration of our progress we naturally give great weight to the developments which are reviewed in the committee reports and to the completeness of the technical program of the convention. It is, of course, true that our conventions and our regional meetings record the advances which have been made in the electrical field, but we must not let the knowledge of this fact obscure in our minds the progress that finds its real and solid foundation in the Section meetings; for after all, it is largely in the Sections that the men are developed upon whom much of the progress depends.

I can think of no message of more importance with which to close the year than one that emphasizes again the opportunities of the Sections. The new chairmen and committees will soon be completing their plans for the coming year. The suggestions contained in last January's message may be of help. No more successful plan has been found than one that gives the fullest opportunity for the development of the individual member.

Our incoming president has a deep-seated interest in the Sections, already expressed in many ways and particularly in his three years of splendid service as chairman of our Sections Committee. With his whole-hearted, sympathetic, and active support, supplemented by the organized facilities of our excellent headquarters' staff, the progress of the Institute is assured and the electrical engineers of America will have cause for increasing pride in their profession, and in the society of their profession.

R. F. Schuchardt

President

Some Leaders of the A. I. E. E.

Frederick Bedell, member of the Institute since 1892, Manager 1914-17, and Vice-President 1917-18, was born in Brooklyn, N. Y., April 1868. After an undergraduate Arts course at Yale, he took graduate courses in science, engineering and mathematics at Cornell University, receiving the degree of Doctor of Philosophy and joining the instructing staff in 1892. In 1893 he was appointed Assistant Professor of Physics, and, in 1904, Professor of Applied Electricity, a position he still holds.

Doctor Bedell has performed valuable service to the Institute not only by contributing papers—many of which are outstanding,—and by participating in discussion, but also active service in its principal committees, as member of the Meetings and Papers, Standards, Library and Sections committees, Chairman of the Electrophysics Committee and of the Subcommittee on Wave-form Standard, and as member of the committee of award of the Edison Medal and for many years as director. With his clarity of vision his influence on the electrical engineering profession has been marked.

His most important contributions in electrical engineering have been his experimental investigations and theoretical studies dealing with alternating currents, a field in which he was a pioneer. His first paper before the Institute in 1892, on the *General Solution for the Current Flowing in a Circuit Containing Resistance, Self-Induction and Capacity, with any Impressed Electromotive Force* introduced the use of *j* as an operator in the solution of alternating-current problems. This and other papers written in collaboration with Doctor A. C. Crehore, developing analytical and graphical methods for solving alternating-current problems now well known, formed the basis of the book "Bedell and Crehore's Alternating Currents" which was the first systematic treatise in its field, and for many years a standard text. It received world-wide circulation in several languages. The principles first enunciated in it have been included in nearly every book dealing with alternating currents that has subsequently appeared.

In addition to about one hundred articles, Doctor Bedell has published the following three books on electrical engineering: 'Alternating Currents," "The Principles of the Transformer" and "Direct and Alternating Current Manual." In these he has had many "firsts" to his credit, including the circle diagram for the transformer in 1893 (extended later by others to include the induction motor), the first paper on "reactance" (jointly with Steinmetz, TRANSACTIONS, 1894) the introduction of "reactive power," the first graphical analysis of the operation of the synchronous motor (with Ryan, *Journal Franklin Institute,* 1895) and the predetermination of transformer regulation. In a three-page paper with Crehore in 1892 (*American Journal of Science*) he called attention to the limitations of the telephone due to the differences in the rates of decay of high and low frequencies, and pointed out that this effect was diminished by the introduction of self-induction, a theoretical deduction substantiated later by the general use of loading coils. The principle of reciprocal vectors was presented in a paper on "Admittance and Impedance Loci" before the Physical Society of London in 1896.

The same high standard has been attained in his contributions to mechanical and aeronautical engineering. His books "Airplane Characteristics," "The Air Propeller," and "The Airplane" rank high in their field; in them the principles of flight have been clearly developed without being encumbered by structural minutiae on the one hand or by abstruse mathematics on the other.

In the field of physics his work has been no less noteworthy. For twenty-nine years he was editor of *The Physical Review,* a period in which physics in this country—as well as electrical engineering—developed from youth to maturity. The principal American contributions to physics during this period passed under his scrutiny. He was contributor to Johnson's Universal Cyclopaedia and to the Standard Dictionary and was editor (for electricity) of Webster's New International Dictionary. He has served as secretary of the Council and as General Secretary of the American Association for the Advancement of Science. He has a number of patents, both United States and Foreign, on improvements in transmission of power and intelligence.

Doctor Bedell's present activities are reflected in two papers before the regional convention of the Institute in 1927 on *Non-Harmonic Alternating Currents* and *The Stabilized Oscilloscope: a Cathode Ray Oscillograph with Linear Time-Axis.* In his theoretical work he is at present interested in extending the use of vectors (in some cases in more than one plane) to apply to alternating quantities without the limitation of the so-called sine assumption. He is experimenting on methods for observing such quantities and is completing the development of an improved oscilloscope, extending its use to the study of light and sound, as well as electrical phenomena.

The Engineering Division of Iowa State College, Ames, Iowa, has inaugurated a personnel service which should prove of mutual benefit to the industries and the engineering graduates. With the cooperation of the engineering student council "Personnel Service Leaflets" have been published for the senior engineers and fifty sets of these leaflets were sent to the leading industries early in January. Each year new sets of leaflets will be sent by the college to these industries as well as to other industries that may be interested.

Each leaflet gives a portrait of the student, his name, college course, and date of graduation. Many other details as to his training, experience and qualifications are included in the leaflet, such as his age, health, college activities, expenses earned, etc.

Abridgment of

Master Reference System for Telephone Transmission

BY W. H. MARTIN*
Member, A. I. E. E.

and

C. H. G. GRAY†
Applicant for Membership

Synopsis.—*The telephone transmission system described here is the Master Reference System of the Bell System for the expression of transmission standards and the ratings of the transmission performance of telephone circuits. The transmitter and receiver elements of this system are reference standards for the ratings of the transmitting and receiving performance of terminal station sets.*

A replica of this reference system installed in Paris has been adopted as the Master Reference System of the International Advisory Committee on Long Distance Telephone Communication in Europe. The establishment of these two master systems provides a common reference for the telephone transmission work of the Bell System and the telephone administrations which are members of this International Advisory Committee.

* * * * *

THE Master Reference System for Telephone Transmission, as its name indicates, is to serve as the fundamental circuit in the ratings of the transmission performance of telephone circuits. In describing this system, therefore, it will be advantageous to outline first the general considerations underlying the methods of determining and specifying these ratings and their applications.

The conversions and transfers of energy which constitute the process of telephone transmission result in general in a difference between the speech sounds at the sending end of the telephone circuit and the sounds reproduced at the other end in the ear of the listener. These reproduced sounds may differ from the original in three important respects; their loudness, distortion, or degree to which their wave-shape departs from facsimile reproduction and the amount of extraneous sound or noise which accompanies them. From the standpoint of telephony, the major importance of a difference between the original and reproduced sounds is determined by its effect upon "intelligibility," that is, the degree to which the latter sounds can be recognized and understood by the listener when carrying on a telephone conservation. The tolerable departure of the reproduced from the original sounds is limited also by certain effects which are noticeable to the listener before they materially affect intelligibility, such as loss of naturalness.

Measurements of intelligibility are of utmost importance in rating the performance of telephone circuits, but they are unduly cumbersome for direct use in the detailed development and design of telephone circuits and their many parts, particularly where small effects are concerned. It has been desirable, therefore, to handle telephone transmission work in two steps. One natural division is suggested by the statement that intelligibility is a function of the relation between the output and input speech sounds, and of the psychological reaction of the listener to these output sounds. Because of the complex nature of the speech sound waves, however, it has been found more practicable to treat the transmission performance of telephone circuits in the following two parts: (1) the physical performance of the circuit, and (2) the relation between physical performance and intelligibility. The physical performance of a circuit is taken here to cover the transmission characteristics which can be specified in terms of the performance for single frequencies, a number of frequencies being taken to cover the range which is important for the reproduction of speech sounds. These measurements of physical performance cover such things as the response-frequency characteristic of the circuit over the range of speech frequencies, the distortion due to non-linear elements, phase distortion, and the extraneous currents which cause noise. These determinations of physical performance do not include measurements of the speech sounds themselves, nor of the functioning of the talker and listener. This differentiation is advantageous in segregating the studies of speech sounds and of the psychological phases of the work, and permits the design of the operating plant and a large portion of the development work to be carried out on a physical basis.

The determination of the relation between intelligibility and the physical performance of a telephone circuit is a laborious process, because persons play the parts of generators and meters and a number of people must be used in both parts to take into account the normal ranges of their performance. The goal of this portion of the work, has been, therefore, to establish suitable relations which will permit the determination of the intelligibility of a circuit by computations which start with the physical characteristics of the circuit. This work[1] has involved determinations of the capabilities of circuits having various kinds of physical

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

1. For all numbered references see end of paper.

29-110

characteristics to reproduce intelligible speech, investigations of the nature of speech sounds and hearing, and of people's customs in using the telephone.

Prior to the time when suitable means were available for measuring the physical performance of telephone circuits, and when the kinds of circuits in commercial use were quite similar in their distortion characteristics, the practise was adopted of rating the performance of a circuit by comparing it, on a loudness basis, with a reference circuit which was adjustable in attenuation and whose distortion was closely similar to that of the commercial circuits. In such a comparison, a determination is made of the equivalence of loudness or volume of these two circuits by talking alternately over them and adjusting the reference circuit until the sounds coming out of the two receivers are judged to be equal. For the conditions where volume is the important controllable characteristic of telephone circuits, these loudness comparisons constitute a practicable and effective means of indicating the performance of these circuits.

The reference circuit adopted about twenty-five years ago for these loudness comparisons consisted of transmitters, receivers, station sets, cord circuits and a line, of types which were then used commercially. In this reference circuit the line was an adjustable artificial line simulating a No. 19 A.w.g. cable circuit having a capacity per loop mile of 0.054 μ f. The amount of cable in this line to give a loudness balance was taken as the rating of the circuit under comparison. This reference system has been called the Standard Cable Reference System.

In addition to this rating of the performance of a telephone circuit, the standard cable reference system has had other applications. Certain settings of this reference system were selected as specifying the standards of transmission which were to be provided in the design and operation of commercial circuits for the several kinds of service, such as local and toll. The effect of introducing or changing any part in a commerical circuit was rated in terms of the amount of cable by which it was necessary to change the line of the reference system to produce the same effect on the loudness of the reproduced speech sounds. Likewise, the transmitters and receivers of this reference system were used as reference instruments for the comparison and rating of other transmitters and receivers.

This cable reference system has played a very important and necessary part in the development of telephone transmission, in that it has provided a ready means of rating the performance of the various parts of the system and of any changes, and has made it possible to design commercial circuits to provide a predetermined grade of service. The performance of this system was specified by stating the kinds of apparatus and circuits used. The performance of the elements of the electrical portion of the system could be checked by voltage, current, and impedance measurements, but for the transmitters and receivers, reliance for constancy of performance was placed primarily upon the careful maintenance and frequent cross-comparisons of a group of transmitters and receivers which were specially constructed to reduce some of the sources of variation in the regular product instruments. In this way, reasonable assurance of the performance of the reference system was secured. This system has been widely used both in this country and in other parts of the world, and the performances of the various systems have been kept in accord by frequent circulation of calibrated transmitters and receivers.

As the telephone art has developed, modifications have been found to be desirable in this reference system to make it more suitable for its purpose. Telephone instruments and circuits have been designed and used which have less distortion than existed in the corresponding parts of the cable reference system. For this reason it is desirable to have as a new reference system one with which the transmission over the most perfect telephone circuit or over some less perfect one may be simulated at will. The change of the unit of transmission from the mile of standard cable to the decibel[2] has brought about the need for a change in the line of the reference system.

A reference system such as that described here, in which the essential elements are so constructed as to reproduce speech with a high degree of perfection and with which provision may be made for modifying the speech in definite and reproducible ways, affords a convenient means for studying the capabilities of telephone circuits of different physical performances. These investigations, however, are outside the purpose of this paper, which is to describe the new reference system and its application in making volume ratings.

General Requirements

The outstanding conception of the new reference system is that its performance should be suitable to serve as a reference base line for indicating the performance of all telephone circuits and that the transmitter and receiver elements of the new system should provide similar base lines for the performance of electro-acoustic converters. To meet these needs properly, the performance of the system and its parts should be capable of being measured and definitely specified in terms of physical quantities.

The most important requirement, then, for the reference system is that the physical performance of the system and of its component parts should be capable of being measured and definitely specified in terms of physical quantities.

The second main requirement is that specifiable and predeterminable changes can be made with respect to the performance which is selected as the reference. These changes must be capable of varying the relation between the loudness of the reproduced sounds with respect to the initial sounds, the distortion of the wave-

shape of these reproduced sounds, and also the amount of noise accompanying these reproduced sounds.

For convenience in specifying these requirements, it has been found desirable to impose another requirement; namely, that the system be capable of giving a performance which is as free as possible from distortion and noise. This requirement is also of advantage in insuring that the reference system and its parts will have less distortion than any circuit or instrument with which it may be compared.

For convenience in use, it is highly desirable that the performance of the reference system and its parts be constant for a reasonable time under normal operating conditions.

Description of Master Reference System

The master reference system[3] employs a transmitter and receiver which are capable of a high degree of freedom from distortion. The transmitter is of the condenser type[4] and the receiver is of the moving coil type.[5] Both these instruments are materially lower in efficiency than commercial types of apparatus, but this condition is compensated for by the use of multi-stage vacuum tube amplifiers. These instruments, together with their associated amplifiers, constitute reference standards for converters between acoustic and electrical energy. The third necessary element of a telephone transmission system,—namely, the line,—is provided by a network of resistance elements. Such a line can be made to provide uniform attenuation over a wide frequency range, and can be made to control the magnitude of this attenuation over a large range. This line is taken as giving a reference performance for lines.

The specification of the performance of such a system is based on the principle of the thermophone, which is a converter of electrical energy into acoustic waves by means of the heat generated by the passage of an electrical current through a resistance. From a knowledge of the form and physical constants of this resistance element, of the medium in which it is used, and of the electrical input to the element, the acoustic pressure generated in a chamber of known size can be determined by theoretical considerations.[6] The performance of the condenser transmitter is determined by making its diaphragm a wall of a simple closed chamber in which the thermophone is placed. By this means a known pressure wave of any frequency over the range desired can be impressed upon the diaphragm of the transmitter. The voltage output of the transmitter for a specified circuit condition is then measured. From this measurement the ratio of the voltage output to the acoustic pressure on the diaphragm is established for that instrument and circuit condition. With the performance of the transmitter thus established, the performance of the receiver element of the reference system is measured by acoustically coupling the receiver to the condenser transmitter, so that the receiver actuates the transmitter, and then determining the relation of the pressure generated by the receiver in the coupler to the voltage input to the receiver. The performance of the line element is determined by well-known means. The performance of the whole system can then be expressed in terms of the pressure produced by the receiver with respect to the pressure on the diaphragm of the transmitter.

The performance of this system is practically free from distortion for the energies which it is required to handle, and probably materially excels in this respect that of any previous system. With this system, volume relations between output and input sounds can be varied over a wide range with practically no accompanying distortion. In comparing such a system, however, with commercial systems it is advantageous also to

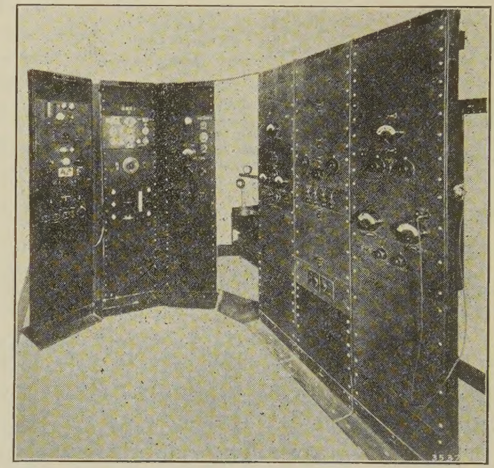

Fig. 1—Master Reference System for Telephone Transmission with Associated Calibration Apparatus

be able to control distortion. This is particularly the case when using the instruments of the master system for rating the volume efficiency of commercial types of transmitters and receivers. To facilitate this, arrangements are made for the introduction into the amplifiers associated with the transmitter and receiver, of networks which may be designed to give a variation of efficiency with frequency which corresponds to that obtained with commercial apparatus. These networks and their distortion effect can of course be definitely specified. The line element of this master system can be replaced by a line or network giving any type of distortion desired. Also, known amounts of extraneous currents to produce noise can be introduced into this circuit without otherwise appreciably affecting its performance.

The master reference system with associated calibration apparatus is shown in Fig. 2. This equipment, mounted on steel panels and racks, and arranged as shown, is installed in a room, shielded from acoustical and electrical disturbances, at the Bell Telephone Laboratories in New York City. In Fig. 2 the transmitter, line, and receiver of the reference system are

shown on the three racks at the right. The calibration apparatus, consisting of an oscillator, thermophone, vacuum tube voltmeter, and volume indicator are shown on the other three racks. A schematic diagram of the master reference system is shown in Fig. 3.

Fig. 10 shows, for particular amplifier adjustments the frequency response characteristics of the reference transmitter, reference receiver and the complete reference system with 0 db. in the line. The characteristic

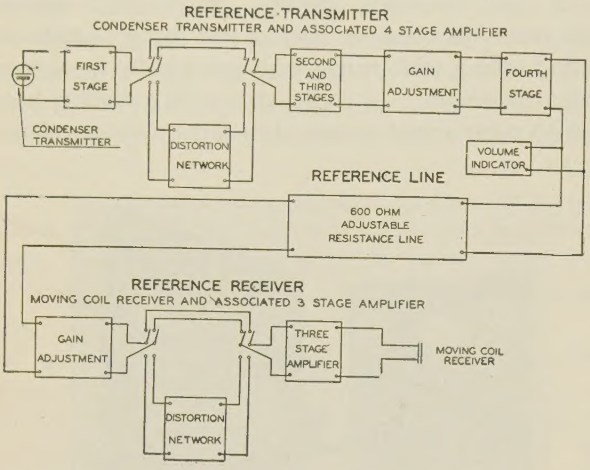

Fig. 2—Schematic Diagram of Master Reference System

of the reference transmitter and also of the reference receiver in each instance is that of the instrument and associated amplifier combined. However, as the frequency response of each of the amplifiers is uniform within 2 db. from about 50 to 10,000 cycles per second, the curves shown are essentially the calibrations of the instruments determined as described above.

Application of the System

The results of articulation tests over the master reference system when adjusted for optimum volume are practically equivalent to those obtained in direct air transmission in a quiet room. This system and replicas of it are particularly adapted for use in making articulation studies, since they provide an approximately ideal system with which the loudness of the output sounds can be varied distortionlessly over a wide range and in which distortion networks of various types and controlled amounts of noise can be introduced. In this way the effects on articulation of various kinds of physical performance of a telephone circuit can be investigated.

The master reference system itself will be used chiefly for the important work of rating working standard systems and instruments.

European Master Reference System

In Europe, the recommendation of technical standards for telephony is a function of the Comité Consultatif International des Communications Telephoniques a Grande Distance (C. C. I.), which is composed of representatives of the various European telephone administrations. In 1926, at the invitation of the C. C. I., representatives of the Bell System met in London with a committee appointed by the C. C. I. to consider the adoption of a transmission reference system. This committee recommended that the C. C. I. adopt as their master reference system one essentially the same as the one described in this paper, and that such a system, which would be a replica of one in New York, be installed in Paris in the laboratory of the C. C. I. and be known as the European Master Reference System. This recommendation was adopted by the C. C. I.

Subsequently, some improvements were made in the system, and two duplicate systems, each with its associated calibrating apparatus, have been constructed. One of these is now in the Bell Telephone Laboratories in New York and the other in the laboratory of the C. C. I. in Paris. The C. C. I. further recommended that primary and working standard systems, used in the telephone administrations adhering to the C. C. I., be calibrated in terms of the Master Reference System.

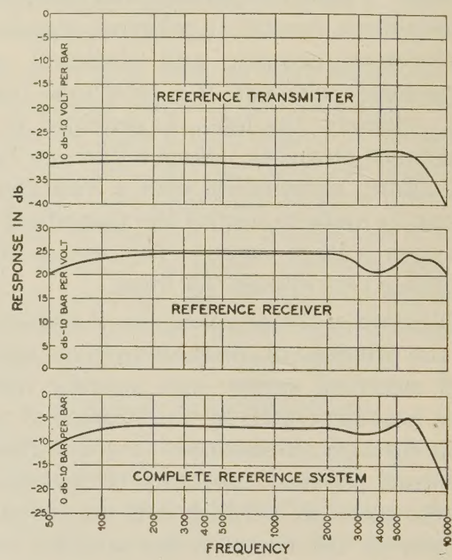

Fig. 3—Response Characteristics of Reference Transmitter, Reference Receiver and Complete Reference System with 0 db. in the Line

The establishment of these two master systems insures the use of a common base line for the expression of transmission standards, and for the ratings of the transmission performance of telephone circuits in the two continents where the telephone system has had its greatest development.

List of References

1. "Speech and Hearing" by H. Fletcher, published by D. Van Nostrand Co.

2. "Decibel" (db) is the name for the Transmission Unit which has superseded the "mile of standard cable," W. H. Martin, *Bell System Technical Journal*, January, 1929, and A. I. E. E. Journal, March, 1929.

3. A discussion of a preliminary model of this system was

given in "A Telephone Transmission Reference System" by L. J. Sivian, *Electrical Communication*, October, 1924.

4. The theory and operation of this transmitter are discussed in papers by I. B. Crandall, *Physical Review*, June, 1918, and E. C. Wente, *Physical Review*, July, 1917, and *Physical Review*, May, 1922.

5. This instrument, which is similar in many respects to one described by E. C. Wente and A. L. Thures in the *Bell System Technical Journal*, January, 1928, will be discussed in a future paper by the same authors.

6. The theory of the thermophone as a precision sound of sound is outlined in papers by H. D. Arnold and J. H. Crandall, *Physical Review*, July, 1917, and by E. C. Wente in the *Physical Review*, April, 1922.

Abridgment of

Shielding in High-Frequency Measurements

BY JOHN G. FERGUSON[1]

Associate, A. I. E. E.

Synopsis.—The purpose and usefulness of shielding in high-frequency measurement are outlined. General principles of electrostatic shielding are developed as applied to simple impedances and to networks of impedances, particularly to bridge networks. Practical applications of these principles to the shielding of adjustable impedances, and in the construction of actual bridge circuits are described.

* * * * *

Introduction

Shielding of high-frequency measurement apparatus has for its immediate object the control of certain electromagnetic and electrostatic couplings, unintentionally introduced in the usual high-frequency circuit. These couplings are represented by stray admittances between the various parts of the system, either direct or to ground, and mutual impedances resulting from stray magnetic fields. In general, the control of these couplings is exercised for the purpose of attaining an accuracy of test that cannot be obtained so readily in other ways.

It may be argued that by extensive separation of the physical parts of circuits and apparatus, any couplings may be decreased in value, and in consequence errors caused by them can be reduced, thus eliminating any need for shielding. But there are obvious limits to the extent to which this method can be employed practically. In the case of electrostatic coupling to ground, it is scarcely of any value, and in any case, excessive separation of the parts of a circuit introduces other errors due to the length of the wiring involved. Accordingly, it is usually necessary where the maximum accuracy is desired, to have recourse to shielding.

Principles of Electromagnetic Shielding

The necessity for electromagnetic shielding is limited practically to wound apparatus such as coils and transformers. It may be reduced to a minimum by using high permeability core material wherever possible in coils and transformers, and by using some form of closed core such as the toroidal type. By these means stray fields may be reduced to a relatively low figure. However, there are cases where the remaining coupling may be objectionable and it is then necessary to use shielding to reduce still further the amount of these stray fields.

Two types of shielding may be used. A high permeability material may be used for the purpose of short-circuiting the stray field. The principles of this method of shielding are described fully in another paper and will not be considered further here.

In the case of air-core coils, which are often of the solenoidal type since the advantage of using the toroidal form is less in this case, and for coils used at very high frequency where heavy magnetic material is not so effective, shields of non-magnetic material may be used to confine the field by the effect of eddy currents. For these shields, a material of high conductivity is used, usually copper, and the principal consideration is the spacing of the shield from the coil rather than the thickness of the shield itself.

There is always a loss in efficiency due to the losses in the shield, and this loss is greater the closer the shield is placed to the coil; that is, the stronger the field in which the shield is placed. However, even with solenoidal air-core coils, very effective shielding may be attained by moderately thick copper shields, spaced about the distance of a diameter from the coil.

Principles of Electrostatic Shielding

In both theory and practise, all measurements assume that between different terminals or junction points of the system there are impedances having values known to a degree of definiteness consistent with the accuracies sought in the test. In an unshielded circuit, it will generally be the case that the elements connected by the various terminals or junction points will not provide impedances so definitely known; or, in other words, will not carry all of the current flowing between the points in question.

Resistors. In the case of the simple resistor such as

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Part 3 of a Symposium of six papers on Shielding in Electrical Measurements.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

pictured schematically in Fig. 1A, there are admittances from different parts of the conductor to other parts of the whole system and in particular to ground. These, of course, act to modify the effective impedance between the terminals and as they vary with the location of the resistor, the result is that its effective impedance is variable and known only for the location in which it has been calibrated. One of the first objects to be accomplished by shielding is to remedy this type of indefiniteness of value. This is done by mounting the elements within a shield of conducting material and in fixed space relation thereto, as shown in Fig. 1B. Thus, the circuit element has direct admittances only to the shield and as these are of fixed value the terminal to terminal impedance becomes independent of the location of the shielded element.

If, then, we connect the shield to any fixed point in the circuit element such as one terminal, all of the current transferred by the shield admittances passes to or from the circuit at this particular point. This concentration of admittance enables the ready evaluation of the effect produced by it when the element is used in conjunction with others in a complete measuring system. We may summarize all of this to form a fundamental rule of shielding; *viz.*, "the association of an element of a system with a shield so that all admittances

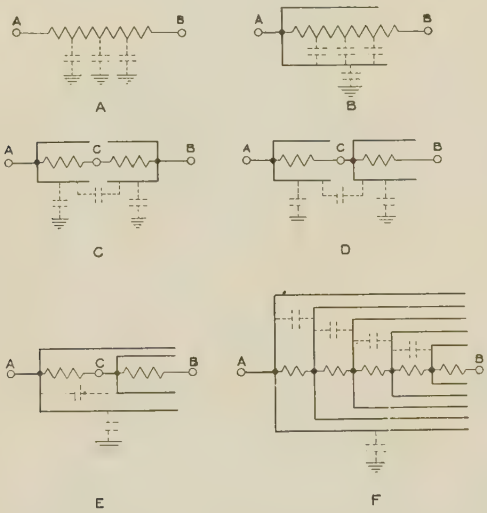

Fig. 1—Methods of Shielding Series Impedances

from the element to other parts of the system or to ground are confined to one terminal."

Series Impedances. In the case of two impedances in series as shown in Fig. 1C, shielding may be accomplished by connecting one shield to terminal A and the other shield to B. In addition to the effects described for a single impedance there will then be admittance between the two shields which will depend on the position of the apparatus. This admittance is slightly more objectionable than admittance from shield to ground, since while we may ground either A or B, there will always be an admittance from one shield to ground which will be variable.

The shields may also be connected as shown in Fig. 1D, in which case the admittance between shields appears across the first impedance. If now we extend the shield connected to A to include the other shield as shown in Fig. 1E, we have introduced a fixed admittance across $A\ C$ and have variable admittances to ground from A.

If this combination of impedances can be grounded at A, we have a complete system having no variable admittances. The principle may be extended to include any number of series elements, the effect being to place admittances across all of the elements but one, and

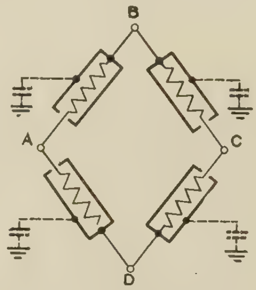

Fig. 3—Bridge Network Using Shielded Impedances

to enclose the whole system in one outer shield. Such a system for five elements in series is shown in Fig. 1F.

Parallel Impedances. The shielding of parallel impedances is comparatively simple, since any number may be shielded individually and the shielding all connected to the same point. If they are not shielded from one another there will be distributed admittances between them which may cause errors. Preferably each should be shielded individually.

By following the procedure outlined above, it is comparatively simple to apply shielding to any combination of impedances in series or in parallel in such a way that we will have all admittances to external conductors from the shielded elements concentrated at terminals or junction points of the system.

Circuit Shielding. In many cases it is impossible to connect the above combinations in a given circuit so that the outer shield is grounded. In such cases it is necessary to determine from the position of the network in the system the effect of admittances from the shield to other shields and to ground. To illustrate, let us take the simple bridge circuit shown in Fig. 3. The four impedances constituting the arms each may be considered as any combination of individual impedances. With the shields connected as shown, the total admittances are reduced to three; between B and D and from B and D to ground. These admittances do not affect the bridge balance and, therefore, are not objectionable. However, if we add input and output circuits and follow the same system of shielding, we get the result shown in Fig. 4. In this case it is impossible to concentrate all of the admittances at B and D. Neglecting for the present the ground at D, we have added variable admittances from A to B, to D and to

ground. The only way of overcoming this difficulty is to use double shielding as shown, adding an outer shield to the impedance across A C and connecting it to D. This puts a fixed admittance across A D, but as we have not made any distinction between the four arms of the bridge, this admittance may generally be placed across an arm where it can be taken care of satisfactorily. If in addition we ground D, the admittances reduce to a single one from B to ground.

Admittance to Ground of Unknown Impedance. From

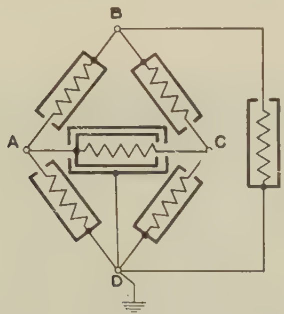

FIG. 4—COMPLETELY SHIELDED BRIDGE NETWORK

the above it would appear that the general bridge circuit is susceptible of a simple complete solution, since the shielding shown in Fig. 4 is equally applicable to all cases. This would be true if the unknown impedance to be measured in the circuit had no admittance to ground. This is usually not the case. We generally have an additional requirement, that the potential condition with respect to ground of the impedance during the measurement be defined in some way.

If the impedance can be connected across one arm of the bridge and its value is desired with one terminal grounded, the circuit shown is satisfactory. However, these are special conditions, and where the impedance to be measured forms only part of the total series impedance of an arm, or where the potential requirements are different, such as the requirement that the coil be measured with its terminals at equal potential to ground, the bridge shielding becomes a more serious problem.

In general, the question of selecting the most suitable system of electrostatic shielding for a specific test circuit, resolves itself into a determination of the most advantageous location of the admittances which, as described above, have been arranged to terminate at certain terminals or junction points. The facts which need to be taken into consideration are usually so varied that no general rules can be established. A few typical examples in which shielding is applied with considerable success will, therefore, be taken and the selection of suitable shielding for these circuits discussed.

EXAMPLES OF ELECTROSTATIC SHIELDING

Adjustable Resistor. An adjustable resistor usually takes the form of a dial box in which there are from one to six dials arranged in series in decade formation. Each decade considered by itself is no more difficult to shield than a single resistor. The admittance of the shield, however, has a different effect at each step which means that the phase angle varies with the setting of the dial. If the admittance to the shield is small, this effect will not be very great and in any case it is always the same for a given setting and hence may be included in a calibration.

In shielding several decades in series, admittances between decades are introduced. Effects due to these admittances can be taken care of completely by the use of nested shields as already shown in Fig. 1F. For a resistance box of five or six dials, this type of shielding becomes prohibitive from a size and cost standpoint and in consequence such shielding is usually not attempted. The use of a single shield for all decades of a resistor means that the impedance of two or more dial settings is not exactly equal to the sum of the impedances of each setting by itself. If the difference is appreciable the only alternative to the expensive type of shielding mentioned above is the use of a calibrated value for every combination of dial settings. This error in additions is smaller the lower the resistance, and usually may be neglected for values below 100 ohms.

In the actual construction of such a resistor it is essential that the shielding be complete, particularly at the dials. Since the effect of the hands in operating the dials is more valuable than any other coupling, it is of very little value to place an unshielded dial box in a metal shield which allows admittance from the hand of the operator to the circuit.

Adjustable Inductor. The same considerations apply

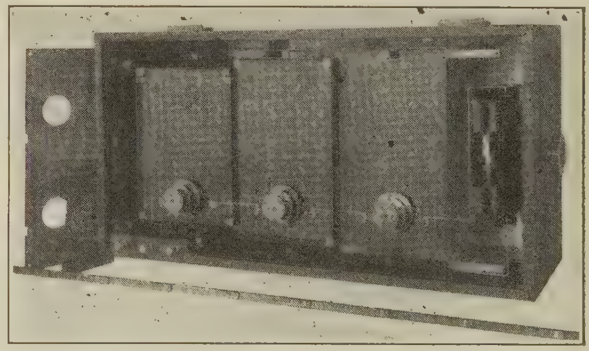

FIG. 6—THREE-DIAL SHIELDED ADJUSTABLE INDUCTOR

to an inductor as to a resistor except that on account of the larger physical size of the former, larger admittances are associated with it and for that reason it is usually necessary to use nested shields. Fig. 6 shows a standard inductor consisting of three decades and an inductometer using four shields. The three top panels have been removed showing the method of nesting the shields, and the construction used to bring the dial controls through the shields.

The admittance between shields is considerable, but due to the method of construction, the largest admit-

tance is across the smallest inductance and there is no intershield admittance added across the highest decade. Accordingly, the effect is not so serious as might be thought at first glance.

Adjustable Capacitor. The units of an adjustable capacitor are practically always connected in parallel and the problem of shielding them is that of shielding a single capacitor. It is desirable to shield the decades from each other if the capacitances are small as this facilitates calibration and is easily effected. Where the capacitance is large,—say over 10,000 $\mu\mu$f.—this precaution is unnecessary.

Bridge Circuits. The general principles of bridge shielding have been discussed by Campbell[3] and the equal ratio-arm comparison bridge has been discussed in detail by Shackelton.[4] The mechanical construction of the bridge itself exclusive of standards is simplified by the fact that there are comparatively few dials to be brought through the shielding.

This bridge with the standards described above may

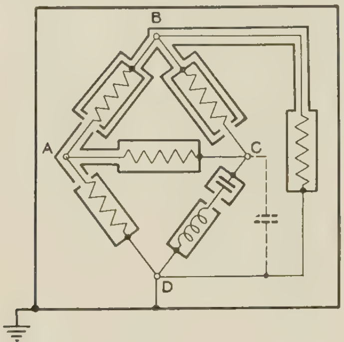

FIG. 7—SHIELDED RESONANCE BRIDGE NETWORK

be used for a wide variety of measurements. A rather simple modification is the so-called resonance bridge, in which the bridge unit is an equal ratio-arm comparison type, and a resistance is balanced in one impedance arm against a capacitance and an inductance connected in series in the other impedance arm. The balance is usually effected by adjusting the resistance and capacitance.

The shielded circuit of such a bridge is shown in Fig. 7. The capacitance from C to D introduced by the shielding may be compensated for in the usual way by the addition of an equal capacitance across $A\,D$. In this circuit, the coil is usually measured under the condition of one terminal at ground potential. Thus, D is shown strapped to the ground shield. For this case, the shielding may be simplified considerably. Fig. 8 shows the mechanical construction of the combined resistance and capacitance standard used with the bridge unit for these measurements. The unit is shown with the top of the outer shield removed. The capacitance, in accordance with the shielding diagram, is double shielded, while the resistance requires only a ground shield.

Another bridge circuit which is interesting from the shielding point of view is the Owen bridge.[5] A detailed discussion of the shielding involved in this type of bridge is contained in a previous paper by the present author.[6]

Details of Construction. So far, we have discussed the admittance introduced by the shielding without going into details as to the form which this admittance takes, although it has been broadly assumed that it is principally due to capacitance. Since it generally forms an integral part of the measuring circuit, it is obvious that

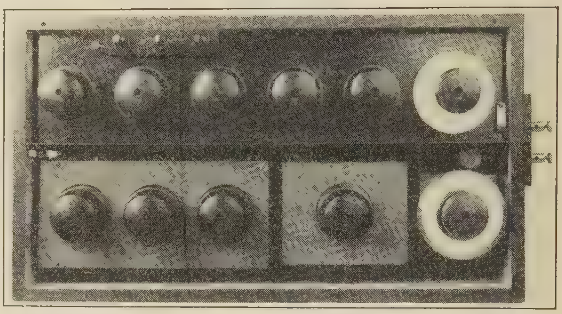

FIG. 8—SHIELDED RESONANCE UNIT, TOP PANEL REMOVES

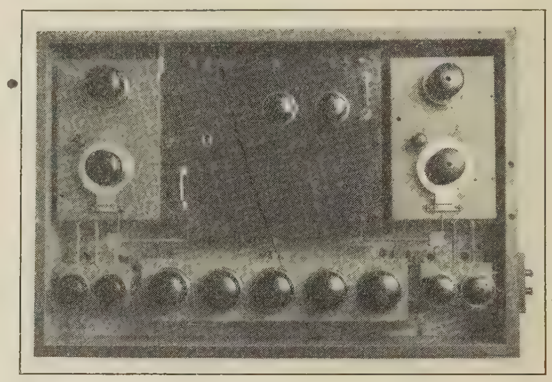

FIG. 9—SHIELDED COMPARISON TYPE BRIDGE, TOP PANEL REMOVED

as much consideration should be given to it as to the rest of the circuit. While the admittance is due essentially to capacitance, the necessary supports introduce a certain amount of conductance which causes some difficulty in obtaining compensation.

For instance, in the typical equal ratio-arm bridge circuit where the admittance across one arm requires compensation in the other arm, it is a simple matter to use an adjustable condenser for the compensation of capacitance. However, if the conductance is left uncompensated it may cause considerable error, particularly in the measurement of high impedances at

3. G. A. Campbell, "The Shielded Balance," *Electrical World and Engineer*, April 2, 1904, p. 647.

4. W. J. Shackelton, *A Shielded A-C. Inductance Bridge*, A. I. E. E. JOURNAL, Feb. 1927.

5. D. Owen, "A Bridge for the Measurement of Self Inductance," *Proc. Phys. Soc. London*, October, 1914.

6. J. G. Ferguson, "Measurement of Inductance by the Shielded Owen Bridge," *Bell Sys. Tech. Jl.*, July, 1927, pp. 375-386.

high frequencies. For this reason, it is desirable that all shields be supported by insulating material of the highest quality such as hard rubber, glass or quartz and that only the minimum amount necessary for satisfactory mechanical support be used.

It will be noticed in Fig. 4 that the wiring is shielded by brass tubing. This shielding is insulated from the conductor by means of bushings, only enough being used to insure that the conductor and shield do not change their relative positions with respect to each other. The insulating bushings used most generally are either hard rubber or glass beads.

Even after taking these precautions, it has been found necessary for the highest precision work at the highest frequencies, to introduce a conductance compensator in the form of a small adjustable condenser in which the dielectric is an insulating material such as phenol fiber. By this means the amount of conductance in one arm may be varied to obtain correct compensation. The balance once obtained, does not vary appreciably with frequency.

Conclusion

It has been impossible to go into very great detail in this brief paper on the subject of shielding. The attempt has been made, therefore, to outline a few general rules and to give representative examples of typical measuring circuits. It will be noted that the examples have been limited largely to the bridge circuit. This is because our experience has shown that this circuit is the most flexible and accurate over the whole of the frequency range over which precise impedance measurements have been made, and because the problems of shielding it are sufficiently difficult and varied to give satisfactory examples of the solution of rather complicated problems. The principles of shielding given have been found to apply equally well at all frequencies and it has been found that up to the maximum frequency at which precision measurements have been made, the shielding methods developed for use with moderate frequencies require practically no modification as the frequency is increased. Experience with measurements and measuring circuits up to 2000 kilocycles, makes it appear probable that when precision measurements are made at still higher frequencies, the shielded bridge circuit will continue to remain the most satisfactory measuring circuit.

Abridgment of

High-Frequency Portable Tools and Equipment

BY C. B. COATES[1]

Member, A. I. E. E.

Synopsis.—*This paper presents practical information regarding the application of high-frequency (180-cycle) induction motors with low-resistance rotors to portable electric tools.*

In order to compete with existing tools it became necessary to increase the rotor speed above 60 cycles, and 180 cycles per second was adopted as commercially practical. Several advantages are shown. Due to a smaller drop in speed with this type of motor than with the direct current and the universal motor, greater power is developed. Because of better speed regulation the life of the cutting tools is longer. Less weight and lower maintenance costs result from this application.

Several new tools for special work are described. The desirable regulation of the frequency converter or motor-generator is given as not exceeding 8 per cent.

Older Types of Tools

The application of the term "high-frequency" to portable tools and equipment is no doubt a misnomer in view of the extremely high radio and other frequencies generally understood to come within the scope of this term. As a matter of fact, the frequency now generally employed in so-called high-frequency portable tools is only three times the usual commercial frequency of 60 cycles per second. However, as the name has come to be quite generally accepted as applied to this class of tools, it will be used here.

Electric drills of the portable type were introduced over 25 years ago and to conform to the prevailing conditions in the industrial plants at that time were wound for operation on direct current. These tools were generally series-wound, but several years later the larger sizes were compound-wound to give better speed regulation, which means higher armature speed at full load with limited free speed and consequently greater brake horsepower.

A few years after the introduction of the d-c. drill, a-c. drills were developed. These were built to operate on 60 cycles and other prevailing frequencies such as 40 and 25 cycles. They of course had good speed regulation, but the weight, due to lower rotor speeds being limited to 3600 rev. per min. at 60 cycles and correspondingly less for the lower frequencies, was somewhat of a drawback.

About 1908 the now well-known universal drill was

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass. Complete copies upon request.

introduced and has met with great favor on account of its ability to operate interchangeably at practically the same speeds on either direct or single-phase alternating current of a given voltage. The universal tool is series-wound with the typical series motor speed regulation, however.

While the falling off in speed under load was considered to be of advantage in some classes of work, it has now been demonstrated that due to the accomplishment of a greater amount of work, sustained speed of the induction motor is generally preferable. This is particularly true of portable grinders as will be shown later.

It is quite obvious that due to the absence of commutator and brushes, as well as the insulated armature winding, the polyphase induction-motor tool has distinct advantages over the d-c. and universal tools, both as regards speed regulation and lower maintenance costs. One factor which has retarded its adoption, however, has been its greater weight due to the low rotor speed on commercial circuits of 60 cycles or less. All electric tools d-c., universal, and polyphase a-c., have always had the handicap of weight as compared with pneumatic tools, except at the sacrifice of sturdiness. Nevertheless, on account of the more convenient source of power supply many users have put up with the greater weight of the electric tool.

In order to reduce the weight of the induction-motor tool it is evident that we must bring the rotor speed up, and we can do this only by increasing the frequency, since the 60-cycle drills were practically all provided with the minimum number of poles. The synchronous speed of a two-pole 60-cycle motor is 3600 rev. per min., whereas the d-c. and universal tool motors have free armature speeds of from 8000 to 16,000 rev. per min. and even higher in some of the smaller sizes. Under load these armatures slow down nearly 50 per cent which still leaves a speed higher than that of the 60-cycle motor.

High-Frequency Tools

A frequency of 180 cycles per second was adopted for the high-frequency portable tools, which gives a synchronous speed of 10,800 rev. per min. in the two-pole motor used. This is considerably less than the average free speed of the d-c. or universal tool, which is very high. This means longer life for the bearings which are generally of the ball type. The slip under normal full load is from 8 to 10 per cent, giving an average loaded speed of about 9800 rev. per min., which is much higher than the load speed of the d-c. or universal tool with its large speed drop. This, of course, means more power with a given size of rotor.

Several factors governed the selection of a standard frequency for these tools. Since it was necessary to obtain spindle speeds which would conform to the modern cutting tools for the drills, reamers, and abrasive wheels, there must be a point where the reduction in weight of the motor due to higher frequencies would be more than offset by the greater weight of the gearing required to obtain the necessary spindle speeds. From this point of view, the desirable frequency was found to be in the neighborhood of 180 cycles per second. Troubles in ball-bearings and difficulty of lubrication at high speed is another limiting factor, although improvement in both directions indicates the possibility of still higher frequencies.

Thus the high-frequency tools meet the requirements of intensified production in modern industry where portable tools are crowded to the utmost and in many cases get very little care. The outstanding advantages due to this application are:

I. Greater increased power for the same weight, due to the higher loaded speeds of the rotor.

II. Reduced weight for a given power output.

III. Practically constant speed at all loads (8 to 10 per cent slip) which results in the accomplishment of more work.

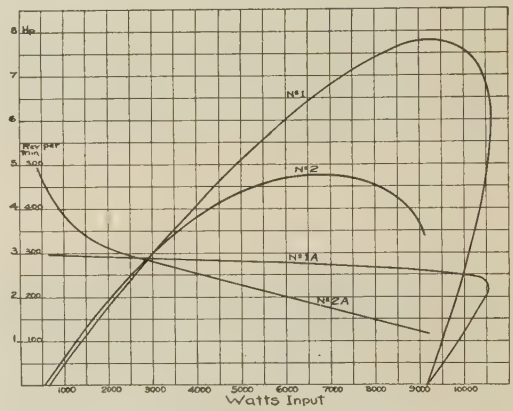

Fig. 2—Comparison of High-Frequency and D-c. Reamers

Curve 1 is brake horsepower of high-frequency reamer
Curve 2 is brake horsepower of d-c. reamer
Curve 1A is speed of high-frequency reamer
Curve 2A is speed of d-c. reamer

IV. Maintenance cost greatly reduced.

In order to give comparisons with other types, a concrete example of the increased power and better speed regulation of the high-frequency tool is shown in Fig. 2. Here the actual watt input is plotted as the abscissas against brake horsepower in curves No. 1 and 2 and against the spindle rev. per min. in curves 1-*A* and 2-*A*. Curves 1 and 1-*A* show characteristics of a high-frequency reamer weighing 50 lb. while 2 and 2-*A* are the corresponding curves of a d-c. reamer which weighs 68 lb. or 36 per cent more. The normal load rating of the high-frequency reamer is 5300 watts input, at which point it develops 5.35 hp. at 280 spindle rev. per min., or with a slip of 6½ per cent. The normal load rating of the d-c. reamer is 3600 watts at which point it develops 3.5 hp. and 265 rev. per min., representing a slip of 56½ per cent. It will be noted that the reserve power above normal full load of the high-frequency tool is large as compared with the d-c. tool. The armature (exclusive

of shaft and the ventilating fan) of the d-c. tool weighs 2⅓ times as much as the high-frequency rotor.

Fig. 3 is the detail curve of the high-frequency reamer shown in the previous curve. Note the well sustained speed at maximum hp. and torque the slip being 15 per cent; also the high power factor.

A cast rotor of relatively low resistance is used in these tools, which gives close speed regulation. When they

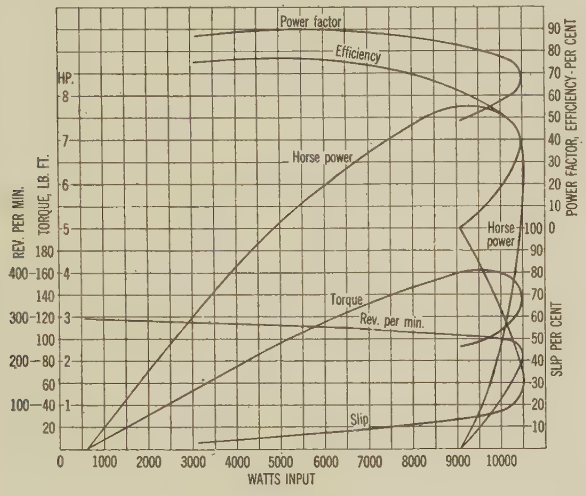

Fig. 3—Characteristics of Large High-Frequency Reamer

were first put on the market it was thought that the smaller tools would be required with considerable speed variation, and a rotor wound with bare copper wire was used making it possible to wind rotors of high or lower resistance as desired. This practise has been discontinued in favor of the low-resistance cast rotor, but a comparison of the characteristics of a small 5/16-in. drill with high-resistance rotor will be interesting.

This drill had a slip of 75 per cent with the torque at the spindle very close to the maximum. The maximum brake horsepower was reached at about 30 per cent slip. With a low resistance rotor in the same stator a slip of 31 per cent was obtained at the same watt input which gave 75 per cent slip with a high-resistance rotor, and the maximum horsepower was developed at 8 per cent slip as against 30 per cent. The maximum brake horsepower was also 12 per cent greater with the low-resistance rotor, these differences being due to difference in rotor resistance.

Perhaps one of the most outstanding examples of the advantages of high-frequency tools is to be found in the portable grinder and buffer. Here the great advantage of sustained speed is very pronounced. The cutting wheel can be operated at the proper and most efficient speed without having to allow a high and dangerous free speed, as is the case with other types of electric and some air grinders. In addition to obtaining the most efficient cutting speeds for the wheels, the wheels themselves give practically double the life at the sustained speeds.

Fig. 5 shows the curves of several types of electric grinders, each having the same weight. The spindle or arbor rev. per min. are shown as the abscissas plotted against the hp.

Curve 1 is of a geared grinder with universal motor and the armature running about three times as fast as the spindle. Note the extremely high no-load speed of 5200 rev. per min., and the speed of 2000 rev. per min. at maximum hp.

Curve 2 is of a geared compound-wound d-c. grinder. The effect of the shunt winding is made apparent in the reduced no-load speed. We also have a greater wheel speed at maximum hp.

Curve 3 is of a two-pole 60-cycle induction-motor grinder without gearing. The synchronous speed is 3600 rev. per min. Here we have good speed regulation and, of course, the absence of gearing is an advantage in that it permits of a larger motor for the same total weight of the tool.

Curve 4 is of a high-frequency grinder geared slightly less than three to one so that the free speed is about 3800 rev. per min. This has good speed regulation and very much more power due to the high rotor speed at full load. This is the only grinder of the group that will successfully carry a six-inch abrasive wheel at proper speed and with sufficient power behind it. The rubber-bonded wheels which permit of a peripheral speed of 10,000 ft. per min. can of course be taken care of by reducing the gear ratio and increasing the arbor speed of

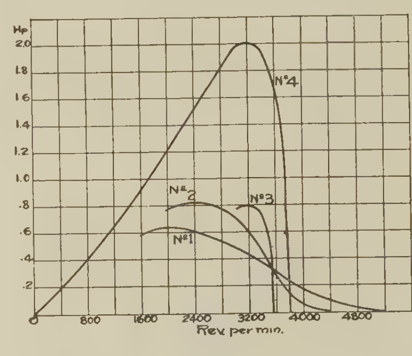

Fig. 5—Comparison of Electric Grinders of Four Different Types

All these grinders have the same weight
Curve 1—Geared universal-motor grinder
Curve 2—Geared compound-wound d-c. grinder
Curve 3—Gearless 60-cycle induction-motor grinder
Curve 4—Geared high-frequency grinder

the high-frequency tool or by using a larger diameter of wheel with the ratio shown.

Just as sustained correct speed makes for longer wear of grinding wheels and abrasive disks, so does it also give long life to reamers and drills. In reaming through a considerable thickness of steel when much metal is to be removed, a tool having great speed variation is apt to produce a clogging of the reamer at extremely slow speeds and burning when the load is lessened with the reamer still in the hole.

A very striking example of the effect of nearly constant speed in increasing the life of the reamer was observed in a bridge fabricating plant with a 50-lb. high-frequency tool, having a synchronous speed of 300 rev. per min. The holes were punched 11/16 in. and reamed to 15/16 in. through assembled plates varying in group thickness from 1¼ in. to 3¾ in. Over 3000 linear inches of this reaming was done with one reamer without regrinding. This was at a reaming rate of 3.7 in. per min., including the time of changing from hole to hole.

As an example of reaming 15/16-in. full-punched holes

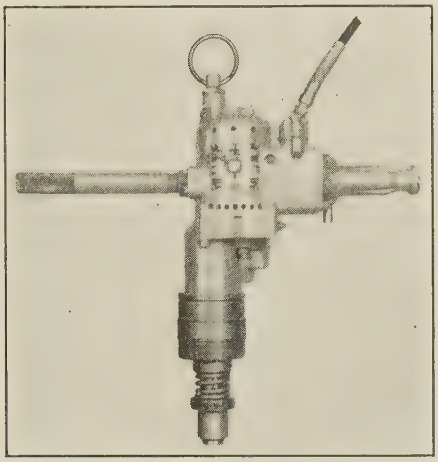

Fig. 8—High-Frequency Nut Runner with Cushion Clutch

in deck plates on ship work, a high-frequency reamer of 300 rev. per min. synchronous speed reamed 100 holes in 9 min., which was 39 per cent faster than with a compound-wound d-c. reamer weighing 40 per cent more.

In the drilling of metal it has been found that high-frequency drills selected as to proper speed for the size and nature of the holes to be drilled will do the work in one-half the time required by the d-c. or universal drills with their greater speed variation.

So much more work can be accomplished with the high-frequency tool that large numbers of the older types of tools are being discarded. Manufacturers are recognizing the rapidly changing conditions and are willing to scrap the earlier tools to invest in the new equipment necessary, in the shape of frequency converters or motor-generator sets and new wiring in order to gain the advantages of increased production. Due to the transformation to the high-frequency current the cost of power is somewhat more but the individual efficiency of the tools is higher than in the old types of tools. As the cost of current in many industries is only about one-twentieth of the cost of production labor, the great increase in productive capacity made possible by the high-frequency tool compensates many times for the slight increase in cost of current.

The outstanding advantages of high-frequency tools have been so apparent that new applications have been springing up with great rapidity. A few of the tool types and their applications will be described in the following paragraphs.

Fig. 8 shows a nut runner for counterbalanced suspension, equipped with a cushion clutch which is adjustable for various sizes of nuts. This clutch which has multiple jaws, releases at a predetermined load and cannot drop into engagement again until the completion of one full revolution. The jaws are quite shallow and there is considerable angular clearance between the interlocking faces, so that when they drop in after having released, the driving faces come together with considerable speed and due to the yielding effect of the spring which holds them together, they ride up and out of contact with practically no shock to the operator or tool.

Fig. 9 shows a large reamer weighing 50 lb. and handled in most cases by two men. This is capable of 1-5/16-in. reaming in steel at a very rapid rate.

Fig. 10 shows a tool for driving screw studs and at the same time indicating their tightness. The tool is carried in a radial arm which is very flexible and serves to take the torque and support the weight of the tool. It has been the custom in putting in screw studs to drive them part way mechanically and then use a double ended wrench to feel them manually for tightness. This was a double operation and slow.

In the construction shown the tool is free to turn on ball bearings around its spindle axis through an angle of 20 deg. or 30 deg. and this movement is resisted by an

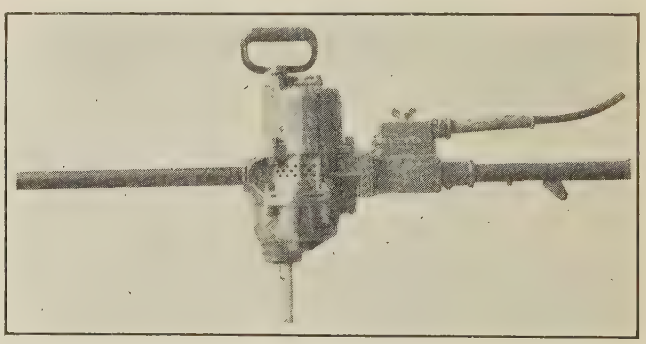

Fig. 9—High-Frequency Reamer

Capacity 1 5/16 in., weight 50 lb.

adjustable weight and lever arm. A so-called solid chuck is generally used which screws over the upper end of the stud and the tool must be reversed to get it off after the stud is driven home. An automatic depth stop, set for the proper length of projection of the stud from the working surface, throws out the driving clutch and stops the tool spindle. The raising of the hand lever at the right engages the reverse clutch and gearing in the tool.

After the tool starts to drive the stud in the tapped hole, the torque developed tends to turn the housing of

the tool against the weight and lever arm shown in Fig. 10, and if this torque is sufficient to lift the weight, an electrical contact is made which causes a green light to appear indicating to the operator that the stud is of the proper tightness. In order to take care of the danger of getting studs too tight, as in cast iron, a second weight and lever are supplied, cooperating with a red light to indicate when the stud is going in too tightly. The excess torque causes the second weight to be lifted and the circuit for the red light to be completed. Current for the lamps is supplied through a small 4-volt transformer.

The radial arm shown in Fig. 10 is also used to carry nut runners as shown in Fig. 8. This relieves the operator of the weight and all shock of driving even when the ordinary solid jaw clutch only is used.

Fig. 11 shows a typical portable grinder for foundry and general grinding. This tool is also furnished with a self-contained angle-gear drive for operating renewable abrasive disks for the sanding of automobile bodies and similar work.

There are many other tool applications which are modifications of those shown. Eight motor sizes comprise the group of tools, Fig. 8 to Fig. 11, with a large number of gear ratios and mechanical combinations.

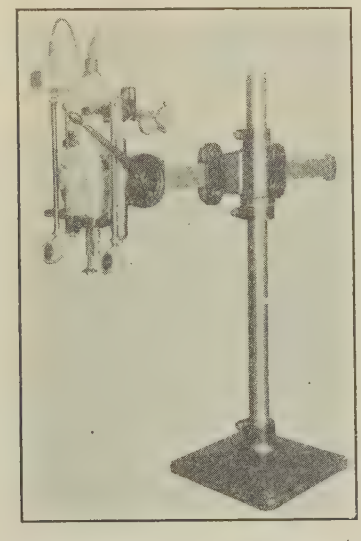

FIG. 10—HIGH-FREQUENCY STUD SETTER MOUNTED ON RADIAL ARM

SUPPLYING THE HIGH-FREQUENCY ENERGY

There are two well-known methods of transforming commercial current to high-frequency current; *viz.*, the frequency converter and the motor-generator.

The frequency-converter can only be used when the primary current is a-c. and consists of special windings in a slip-ring motor frame, the rotor of which is driven backward, usually by an induction or synchronous motor. As satisfactory tool operation depends on good voltage regulation, it has been the aim of the manufacturers to hold within 8 per cent voltage variation, the full-load voltage being 220. The frequency converter has an inherent regulation and the voltage at a given load varies only with the primary voltage.

The motor-generator or alternator provides an entirely new current. The motor can be operated from either direct current or alternating current. If the latter, an exciter will be required for the generator fields. A regulation not to exceed 8 per cent is also desired with this set but it is possible to vary the voltage either manually or automatically by changing the field current of the generator.

The current used for high-frequency tools is three-phase and a cable with four conductors is provided with the tool, terminating in a suitable plug. The fourth conductor is grounded to the housing of the tool and the receptacle in the power line is grounded. This seems to have been satisfactory in the prevention of shocks from grounded windings. It has been suggested that a fourth collector ring be provided on the frequency converter or motor generator to connect to the neutral of the star connected windings and to ground.

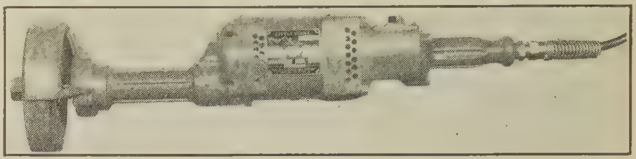

FIG. 11—HIGH-FREQUENCY GRINDER

Wheel 6 in. by 1½ in.

The high-frequency tool has withstood rigorous tests over a period of several years and those who are familiar with its capabilities cannot help but feel that it represents the greatest advance made in portable tools since their introduction.

STREET LIGHTING FORMS AIRWAY MARKER

A new street lighting system has been installed on two converging streets in Cheney, Washington, so as to form an arrowhead of light, pointing in the direction of Spokane. Aviators, when flying at night from the West Coast to Spokane, are able to pick up the lights of Cheney and by following the direction of the guiding arrow, find it a simple matter to locate their destination at the large landing field at Spokane.

The new street lighting installation, designed and manufactured by the Westinghouse Company, was donated to the town by Mayor C. D. Martin, as a memorial to his father and mother who were pioneers in that community.

The system consists of 62 ornamental cast iron standards of the Arcadian design with Sol-Lux Luminaires equipped with Bi-lux refractors and 4000-lumen lamps. The Bi-lux refractors, by providing a symmetric distribution of the light, flood the streets with a brilliant illumination readily discernible from a high altitude.

Electric Welding

ANNUAL REPORT OF COMMITTEE ON ELECTRIC WELDING*

To the Board of Directors:

Your Committee on Electric Welding hereby reports the following activities and developments in their field of activity for the fiscal year May 1, 1928–May 1, 1929.

Meetings and Papers

Our Committee arranged for the presentation of two papers, at the March 1929 Regional Meeting held at Cincinnati, namely, one by Professor F. P. McKibben, on *Arc Welding in Building and Bridge Construction*; the second paper by Mr. H. V. Putman, on *Design and Construction of Electrical Machinery Using the Arc Welding Process of Fabrication.*

American Welding Society Activities

The American Welding Society through its several Committees, has prepared tentative codes on: (1) Recommended procedure for fusion welding of pressure vessels; (2) Fusion welding and gas cutting in building construction; (3) Nomenclature definitions and symbols, and is developing a code for welding for pressure piping.

The Fundamental Research Committee of the A. W. S. is carrying on a number of researches headed by able representatives of eight of the leading colleges in the country, who are making studies under a number of subjects, some of which are as follows:

1. Resistance welds in low and high carbon steel rods.
2. Study of welds at elevated temperatures.
3. Effect of current density and microstructures on strength of welds.
4. Study of weld joints by X-rays.
5. Study of the fundamentals of the welding arc.
6. Study of welded rail joints.

The American Welding Society is carrying on a great deal of additional detailed work too extensive to mention in this brief report.

Commercial Activities

Bridge Construction. During the year a ¼-mile line of overhead railroad construction at a prominent steel mill was reconstructed by the addition of 75 tons of steel.

The Public Service Co-ordinated Transport Co. of New Jersey successfully repaired by arc welding two pairs of poney trusses each 86 ft. long, forming a combination trolley and highway bridge spanning the tracks of the Central Railroad of New Jersey and the Lehigh Valley Railroad at Middlesex Borough near Bound Brook, N. J. This was a very unique operation, requiring 50 tons of new steel and is described in *Engineering News Record* of October 25, 1928.

At the present time, the Harahan Bridge at Memphis, Tenn., is being reconstructed and widened which work will involve a total of 250 tons of steel. As an indication of the saving possible in this class of work, we cite the following figures, namely, an average of six bids for riveted reconstruction $15,060 as against an average for the bids by welding construction of $10,750. This represents a saving of 28½ per cent by welded reconstruction as compared with riveted reconstruction work.

Office Buildings, etc. The Homestead Hotel at Hot Springs, Va. has had a 12-story addition made thereto by the arc welding process, the addition involving 550 tons of steel. The principal consideration in this operation was the elimination of noise, which would have disturbed the guests in the old hotel structure immediately alongside of the new structure. It is difficult to put a direct monetary value upon the elimination of excessive noise for such a proposition.

A combination office and bank building, involving 250 tons of steel, was erected at North Tonawanda, N. Y. for the Tonawanda Power Co.

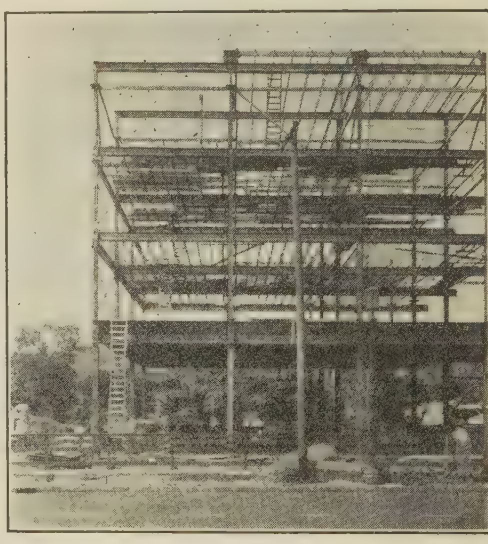

Fig. 1—Cleveland Office Building. Illustrates Decrease in Weight of Columns from the First Floor to the Fourth Floor

An office and store building (Upper Carnegie Bldg.) involving 115 tons of steel was completely erected by the arc welding process, using no rivets or bolts, in the City of Cleveland, Ohio, see Figs. 1, 2, 3, and 4.

Factory Type Buildings. Two buildings of this type were constructed in California for the Southern California Edison Co. at Portersville and Visalia, Calif. A building approximately 50 ft. by 100 ft. was con-

*COMMITTEE ON ELECTRIC WELDING:

A. M. Candy, Chairman,

C. A. Adams,	O. H. Eschholz,	J. C. Lincoln,
P. P. Alexander,	H. M. Hobart,	Ernest Lunn,
C. W. Bates,	C. J. Holslag,	A. M. MacCutcheon,
Ernest Bauer,	C. L. Ipsen,	J. W. Owens,
Alexander Churchward,		Wm. Spraragen.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

structed by welding at Los Angeles. Several additional small buildings in California were constructed by welding, with trusses from 40 ft. to 75 ft. span. The American Milling Co. of Omaha, Neb., has built a large hay barn 75 ft by 190 ft., using 100 tons of steel. In central Florida 15 arc-welded buildings have been constructed, principally for citrus packing houses. The largest of these is 117 ft. by 202 ft., containing 200 tons of steel. One building (Fig. 5) is now nearing completion at North Trafford City, Pa., involving 800 tons of steel and floor space in excess of 100,000 sq. ft. A portion of this operation involves a structure three stories in height, the remaining portion being single story construction.

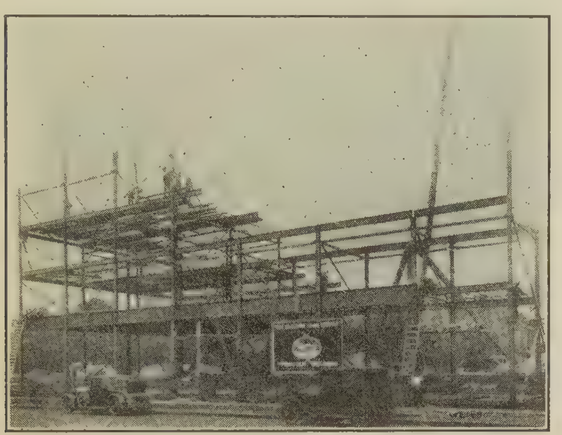

Fig. 2—Shows Framing Partly Erected with 36-In. Girder Welded in Position

Fig. 3—Detail View Illustrating Welded Joints in 36-in. Girders and Location of Welded Open Beams for Supporting the Floor

Thirty-two municipalities in California and eight in Oregon, Louisiana, Mississippi, Arkansas, and Arizona now have sections in their building codes covering the welding of buildings.

According to the new building code sections for these cities, it is now legal for the Commissioner of Buildings in each place to grant, in the same manner as for riveted frames, permits for the erection of electrically welded steel frame buildings.

Pipe Welding. Several installations for welding two lengths of pipe together in the shop to make approximately 40-ft. lengths out of approximately 20-ft. lengths of pipe have been made during the past year. Also some installations for welding longitudinal joints to produce piping in the shop have also been made.

Considerable progress was made during the past year in electric welding gas and oil pipe lines. The method of making the weld, the size of electrode, and welding conditions have been determined for best results and experience has demonstrated the effectiveness of this procedure. Methods of testing the welds have been worked out so that a minimum of interference with the welding procedure is encountered and yet the tests are very effective for determining the quality of the welds.

The welding of pipe lines of municipal water supply has progressed rapidly during the past year. Automatic welding machines and procedure control specifications have been developed for this work. Welding technique and testing methods have been determined to insure uniform results on a production basis. The effect of these developments has been to reduce the cost of pipe lines for city water supply systems.

Fig. 4—Shows the Building Partly Completed

Between 1400 and 1500 miles of pipe line for carrying oil are now being laid in Texas and the South West.

Figs. 6 and 7 illustrate the welding of pipe on one of these lines.

This line is owned by the Texas Pipe Line Co. and has its sea terminus at Port Arthur and runs 714 miles to a place called Monahans, not far from El Paso, Texas.

This pipe carries oil at a pressure of 800 lb. per square inch.

The process of laying the pipe is to get on an average of five 40-ft. lengths lined up on skids along the same axis so that the ends of the pipes being welded are square with each other and weld these five lengths together, turning the pipe every once in a while so that the welder is welding in a substantially downward position. These

welds are made at the rate of 12 to 14 per day per operator.

Two welds are made on each pipe, a so-called burning in weld and a finishing weld.

One end of each pipe is bell mouthed, and the small end of one pipe is inserted in the large end of the next pipe preparatory to welding.

After the five lengths of pipe are welded into sections the bell mouth end of one section receives the small end of the next section and the two sections are welded together.

This weld is called a "bell-hole weld" and part of this weld must be made overhead. The average rate of making bell hole welds is 8 to 10 per day per operator.

After the pipe is welded, it is lowered into a trench which has been prepared for it and later covered.

The outside of the pipe is protected with a heavy coating of asphaltic material to prevent the earth from coming into contact with the pipe so as to prevent corrosion.

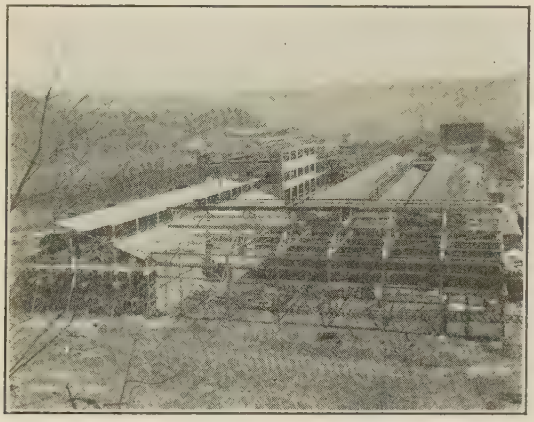

Fig. 5—Building Comprises Three Units in a U Group. Tranverse Unit in Foreground is 133 Ft. by 60 Ft. Longitudinal Building at Left is 441 Ft. by 62 Ft., 140 Ft. of which is Three Stories in Height. Longitudinal Building at Right is 460 Ft. Long by 62 Ft. Wide. A Combined Office and Shipping Building at Extreme End Gives a Total Floor Space in Excess of 100,000 Sq. Ft.

After the pipe is welded it is tested with hydrostatic pressure for tightness, after which the pipe is laid in the trench and covered.

The illustrations show in some detail the process as it is being carried on.

The welding machines are gasoline engines driving welded sets and these may be transported on wagons or may be dragged from point to point by trucks.

Pressure Vessels. During the past year or so two companies have developed special technique and methods for arc welding of heavy steel plate, oil cracking stills, and other high pressure vessels. One of these companies, for example, has manufactured over a thousand vessels using over 70,000 tons of plates averaging about 3 in. in thickness. Excellent ductility and tensile strength are obtained by the methods used by these two companies which employ covered electrodes with special alloys, heavy currents, and annealing of the structure after welding.

Resistance Welding. The use of spot welders, tubing welders, and flash welders has extended rapidly, especially in the automotive field, during the past year. Probably the latest large development in the resistance welding field is that of applying flash welders for producing pipe in commercial lengths, up to about 30 in. in diameter by ⅝ in. in thickness, requiring several thousand kv-a. of power to make each longitudinal weld.

Fig. 6—Bell Hole Welding on 12-in. Pipe Line near Welch, Oklahoma. Observe Bends in Pipe Due to Uneven Terrain, which Causes no Failures

Machinery Construction. The use of welded machine structures replacing castings has received great impetus during the past year, especially amongst the manufacturers of electrical apparatus. The stator for a 160,000-kw. turbo generator has recently been constructed of arc welded steel. (Figs. 8 and 9.) It is undoubtedly safe to say that at the present time such construction by several of the leading manufacturers in the United States has reached the point where not less than 2000 tons per month of such fabricated machines are being produced.

Fig. 7—Typical Finished Welded Joint in 12-In. Pipe Line

Ship Construction. Metal arc welding is being used extensively in the construction of merchant and naval ships. In both cases, the policy pursued is that of a gradual utilization of the process, rather than an attempt to weld the complete ship. In merchant ship con-

struction the object is reduction in cost, while in naval work, the object is to save weight.

International attention has recently focused on arc welding in naval construction because the weight

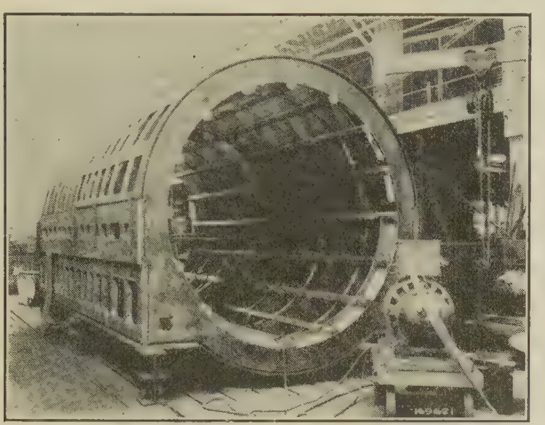

Fig. 8—Frame for 100,000-Kv-a., 3600-Rev. Per Min., Turbo Generator which Weighs Complete 265,000 Pounds and was Shipped as a Unit with Windings in Place. If a Cast Frame had been Used the Weight Would Have Exceeded the Maximum Car Capacity Forcing the Completing of the Machine on Customer's Property Instead of at the Factory

saved by its use materially assisted the German Navy to mount eleven-inch guns on their new 9000-ton cruisers.

The steam ship Virginia, built during the year by the

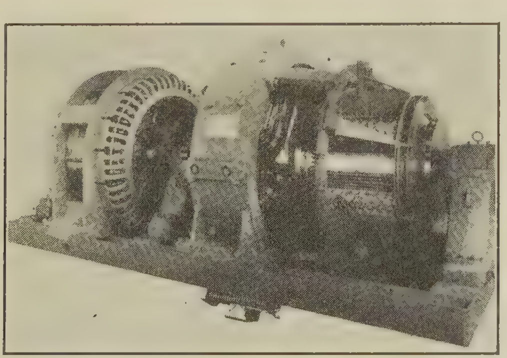

Fig. 9—Shows a Welded Motor-Generator Set the Only Castings Used being the Pedestal Bearings. Even the Brush Rigging for the Generator is of Welded Steel Construction. This Set is Rated at 750 Kw., 900 Rev. Per Min.

Newport News Shipbuilding & Drydock Co. for the Panama Pacific Steam Ship Co., embodied sufficient welding in its construction to require the use of 43,000 lb. of electrode welding wire.

Arc welding has also been used extensively in the construction of the 272-ft. yacht *Viking* for Wm. Baker. In this case, it greatly assisted the architects in obtaining the desired graceful lines.

The Fore River Yard of the Bethlehem Shipbuilding Corp. has constructed a number of bulkheads wherein one row of rivets was replaced by a continuous weld.

The Federal Shipbuilding and Drydock Co. of Kearny, N. J., have recently completed two all-welded channel type scows each 116 ft. long, 34 ft. wide, and 10½ ft. deep.

Miscellaneous. The use of automatic welding equipment has increased materially but to date its possibilities have been appreciated by only a very limited section of industry.

Atomic hydrogen has found many new applications on alloy steels and nonferrous metals. For welding thin sheet steel below No. 16 gage this process has been applied very satisfactorily where smoothness of finish and good ductility are required.

Summary

There are a great many other individual welding applications which might be mentioned but we believe that the above brief résumé summarizes the principal activities in the welding field and will give an insight into welding developments for those who are not directly identified with welding work.

CORRESPONDENCE

STRAY LOSS MEASUREMENTS

To the Editor:

I wish to submit a discussion of Mr. M. C. Holmes' paper on *Separation of Stray Losses in A-C. Generators** as follows:

I believe that Mr. Holmes has given a very clear and correct interpretation of his experimental results. To add some further verification to his conclusions, I may say that we have made several calorimeter tests on turbine generators and found that the load losses at the normal voltage, zero per cent power factor, over-excited condition were substantially the same as those measured on short-circuit. Recently we have made similar tests on some rather large machines at 80 per cent power factor and found the same conditions. In none of these machines was the pole face loss abnormally high, yet, if anything, the load loss at normal voltage was a little greater than that measured on short circuit.

We have made calculations† to determine the axial depth of flux penetration in the armature iron near the ends of the machine, and obtained results comparable to those shown in Fig. 8 of Mr. Holmes' paper.

I should be greatly interested to know how Mr. Holmes determined the volume of iron to which a given measured rate of loss should be attributed in the cases where the iron is thick and the consequent depth of flux penetration might need to be considered; *i. e.*, where the entire thickness of iron probably would not have as high a rate of loss as was measured at the surface by means of the temperature detectors.

J. F. Calvert.

*A. I. E. E. *Jl.*, March 1929, p. 224.

†*Iron Losses in Turbine Generators*, by C. M. Laffoon and J. F. Calvert, A. I. E. E. Quarterly Trans., 48, Part 3, 1929.

Abridgment of

Outdoor Hydrogen-Ventilated Synchronous Condensers

BY ROBERT W. WIESEMAN*

Member, A. I. E. E.

Synopsis.—Hydrogen is an excellent cooling medium for high-speed rotating electrical machinery. When it is substituted for air, a machine can be operated at a higher load with the same temperature rise and the windage loss is decreased to one-twelfth. Furthermore, since no oxidation can take place in this type of machine, the life of the insulation is increased and short circuit and corona troubles are very materially reduced. The machine is especially quiet, and it can be placed out of doors without increased expense.

The first commercial application of hydrogen cooling for electrical machinery was made on a 12,500-kv-a. outdoor synchronous condenser. Another outdoor hydrogen-cooled condenser designed along these lines rated 20,000 kv-a., is also in operation. Both condensers were placed in service in 1928 and their performance has been very satisfactory. This paper describes the construction of the machines and reviews the advantages and disadvantages of hydrogen cooling.

* * * * *

I. INTRODUCTION

Advantages in Ventilating a Machine with Hydrogen

THE characteristics of hydrogen gas, which makes it desirable as a cooling medium for high-speed rotating electrical machinery, are as follows:

Low Density of Hydrogen. Hydrogen is a colorless, odorless, tasteless gas whose density is only 7 per cent that of air. The windage loss of a rotor is approximately proportional to the density of the gas in which it rotates. Thus, the windage loss of a rotor running in an atmosphere of pure hydrogen is only 7 per cent of the air loss. It was found to be entirely practical to maintain a gas mixture in a machine of 99 per cent hydrogen and 1 per cent air, etc., and so a windage loss of only 8 per cent of the air loss is realized. The decreased windage loss also decreases the amount of heat to be removed from the machine, and the size of the surface cooler can be reduced when hydrogen is used as a cooling medium. The bearing friction loss is the same in hydrogen as in air.

High Thermal Conductivity of Hydrogen. Hydrogen conducts heat about seven times better than air and the specific heat of a gram of hydrogen is about 14.5 times that of a gram of air. Consequently, heat passes across the small spaces in the insulation and between the laminations, etc., much more readily than with air cooling; and so the internal copper temperature, for a given surface temperature, is less in hydrogen than in air.

High Forced Heat Convection of Hydrogen. In an atmosphere of hydrogen 30 per cent more heat can be transferred from heated surfaces than in air with the same surface temperature drop. Furthermore, when the hydrogen comes in contact with a surface cooler, more heat can be transferred to the cooler than with air. This again enables a smaller surface cooler to be used; or with the same cooler a lower cooling medium temperature is realized, and the internal temperature of the coil is still further reduced. The bearing temperature is also less in hydrogen than in air.

The reduction of windage loss, the increased thermal conductivity and forced heat convection of hydrogen result in an increased output of 25 per cent or more, depending upon the hydrogen pressure used, the type of ventilation employed, the degree of saturation in the magnetic structure, and the stability required.

No Combustion Possible in an Atmosphere of Hydrogen. There is no oxygen or dirt present in the machine, and, consequently, a combustion cannot take place. This eliminates the need of fire extinguishing apparatus. The burning of iron and insulation following a ground or short circuit is reduced to a minimum. The insulation retains its flexibility, and its life therefore is greatly increased. The bearing lubricating oil remains clean and it does not oxidize or sludge so readily as in an air cooled machine.

Detrimental Effect of Corona Reduced to a Minimum. The thickness of the armature coil insulation is governed partly by the high-voltage gradient and the formation of corona in the minute spaces of the insulation. Tests have demonstrated that the damage caused by corona is practically absent in an atmosphere of hydrogen.[1] Not only will this increase the insulation life, but it will allow a thinner insulation to be used or a greater factor of safety to be secured. These factors will not only make it easier to build machines of present day voltages, but they will make it possible to employ higher voltages in the future.

Finally, the absence of corona damage to varnished fabric insulations will permit their use on high-voltage machines with a substantial decrease in cost. The greater impulse voltage strength of varnished fabric as compared with mica insulation thus gives the hydrogen-cooled machine a further advantage for installations where high-voltage surges are likely to be experienced.

Outdoor Operation. At practically no increase in

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

1. For references, see Bibliography.

cost a hydrogen-ventilated machine can be made suitably weather-proof for outdoor operation. This effects a great saving in building expense.

Quiet Operation. The windage noise of a totally enclosed hydrogen-cooled machine is very much less than that of an air-cooled machine. Thus, a hydrogen-cooled machine is exceptionally quiet and it can be placed outdoors in a residential district where a noisy machine would be very objectionable.

Disadvantages in Ventilating with Hydrogen

Safety Precautions. When hydrogen cooling was first proposed, some difficulty in preventing accidental explosions was anticipated. The increasing familiarity with the problem and the extensive use of hydrogen for many indistrial purposes, such as brazing, annealing, welding, etc., indicate that there should be no difficulty with this problem. The Schenectady factory of the General Electric Company uses 30,000,000 cu. ft. of hydrogen per year without experiencing any difficulty from this source. Every city has one or more gasometers containing many thousands of cubic feet of gas which though not explosion-proof give practically no trouble. The following table gives the stored energy in a steam boiler, in a large turbine-generator rotor, and in the gas of a hydrogen-ventilated synchronous condenser when it contains the most explosive mixture of air and hydrogen:

	Stored energy ft-lb.	Per cent
Steam boiler 2000 boiler hp	$25{,}000 \times 10^6$	100
Large turbine-generator rotor	300×10^6	6.0
Hydrogen-ventilated machine containing 1000 cu. ft. of the most explosive mixture of air and hydrogen at atmospheric pressure	70×10^6	1.4

It is quite evident that a hydrogen-ventilated synchronous condenser has very much less potential explosive force than other apparatus in common use.

A mixture of hydrogen and air will not explode if the hydrogen content, by volume, is more than 70 per cent or less than 10 per cent. If a machine is scavenged with carbon dioxide before it is filled with hydrogen, no explosion can take place when it is started for the first time. The hydrogen pressure in the machine is automatically maintained slightly above atmospheric pressure. This prevents air from leaking into the machine, and eventually the hydrogen purity will reach that of commercial hydrogen which is usually around 99 per cent. It has been found that a hydrogen purity of 98 per cent can be obtained in a few hours after a machine is filled with hydrogen. A hydrogen purity indicator can be made to ring an alarm if the purity falls below normal. A fan pressure gage calibrated to read hydrogen purity gives an instantaneous reading of the hydrogen purity in the machine when it is in operation. Thus, the possibility of an explosion is very remote if the machine is given ordinary supervision.

Increased Disassembly Expense. If a hydrogen-ventilated condenser must be disassembled for repairs, more time will be consumed and more expense will be involved than with a standard air-cooled machine. On the other hand, it should not be necessary to dismantle the hydrogen-ventilated machine so often because of its longer insulation life, its lower bearing and internal coil temperature, and the absence of dirt. It is believed, therefore, that the total maintenance expense over a period of years will be less for the hydrogen-cooled machine.

II. Hydrogen Cooling can be Easily Applied to a Synchronous Condenser

It is unnecessary to have the shaft of a condenser extend through the gas-tight shell as in the case of a turbine generator, and so a seal[2] of any kind around the shaft is not required. With this arrangement, the construction of the machine is simplified because the entire machine, including the bearings and shaft, can be enclosed in a gas-tight shell.

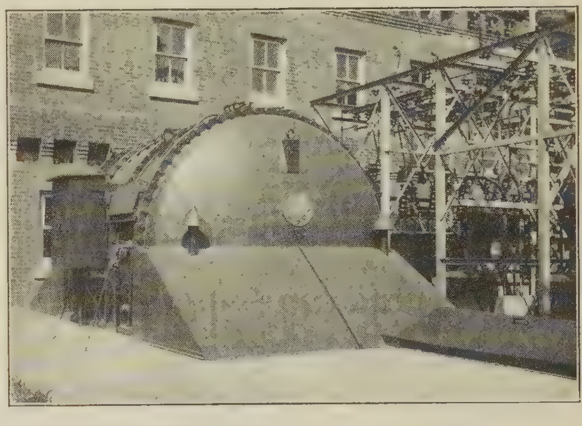

Fig. 1—The First Outdoor Hydrogen-Ventilated Synchronous Condenser, 12,500-Kv-a., 900-Rev. per Min., Three-Phase, 60-Cycle, 13,800-Volts. New England Power Co., Pawtucket, R. I.

III. Description of Outdoor Installation

Fig. 1 shows the 12,500-kv-a. hydrogen-ventilated synchronous condenser completely installed at the Pawtucket, R. I. Substation of the New England Power Company. This condenser is the first of its kind ever built. It is located out of doors without any protection from the weather, but is placed over a pit which is made weather-proof by a substantial sheet-iron covering. Along side of the condenser are located the switches, starting compensator, transformers, and lightning arresters. Fig. 3 is a sectional view of the machine. These views show the semi-circular surface coolers, the bearing housing and its fabricated support, the high-voltage armature terminals, the collector housing, and the construction of the gas-tight frame. The bearings

can be filled with oil and drained without dismantling the machine or losing any hydrogen.

The 20,000-kv-a. condenser located near Charleston, W. Va., at the Turner Substation of the Appalachian Electric Power Company is also placed out of doors and it has the same design as the 12,500-kv-a. condenser except that its capacity is higher. The field collector is located in a small housing which is bolted to the end head.

In the weather-proof pit beneath the condenser are located the cooling water circulating pump, the oil pump for filling the bearings and furnishing high pressure oil for starting, the hydrogen supply tanks, the hydrogen pressure gage, the indicating thermometers, the automatic hydrogen pressure control, the rotor fan pressure gage for indicating the hydrogen purity when the machine is in operation, the thermal cell of the hydrogen purity indicator which indicates the hydrogen purity at all times, and the various valves for controlling the water, oil, and hydrogen.

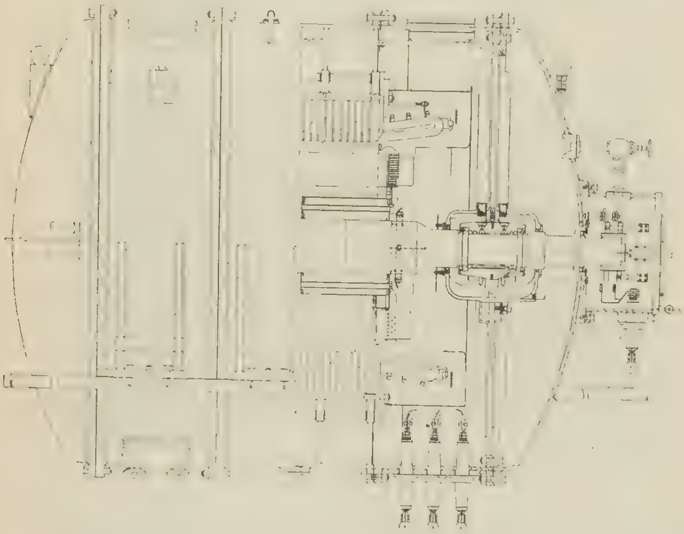

Fig. 3—Sectional View of the 12,500-Kv-a. Hydrogen-Ventilated Synchronous Condenser

IV. Explosion-Proof Frame

The stator frame consists of three sections and two heads bolted together as shown by Fig. 3. The main joints of the frame are gasketed gas-tight and they have practically no hydrogen leakage. The large middle section holds the armature punchings and windings and the two smaller sections hold the internal surface coolers and bearings. The frame is fabricated entirely from steel plate. The elimination of castings, which are sometimes porous, is not only in keeping with present day dynamo machine construction, but it also insured minimum hydrogen leakage.

In order to minimize the effect of an explosion resulting from careless operation, these condensers were provided with a cylindrical explosion-proof frame designed to resist the disruptive force of the most explosive mixture of hydrogen and air at atmospheric pressure. The frame of the 12,500-kv-a. condenser without windings, coolers, and piping, was filled with the most explosive mixture of air and hydrogen, and the gas was ignited with a spark plug. No damage resulted from the explosion which developed a maximum pressure of 85 lb. per sq. in. as recorded by an instantaneous pressure recorder. If the machine had been completely assembled with all of the various metallic parts, especially the coolers, the pressure would have been only about 50 lb. per sq. in. This test also showed that an explosion would have no detrimental effect on the insulation. It is very unlikely that the gas in the machine will ever reach the most explosive mixture of air and hydrogen of 5 to 2 by volume. For any other gas mixture, the explosive force would be very much reduced. The theoretical pressure of 180 lb. per sq. in. with an air-hydrogen explosion could be obtained only if no heat were absorbed by the explosion chamber and its contents.

VII. Hydrogen Ventilation

Each end of the frame contains two-semi-circular surface coolers. The cooler heads can be removed and the tubes cleaned without dismantling the machine or losing any hydrogen. The four cooler units are piped in multiple, and air vents and drain valves allow the coolers to be thoroughly drained to prevent any water in the cooler from freezing in the winter if the machine is not in use.

The rotor poles and fans force the ventilating gas through the stator ducts to the back of the stator frame. Then the gas passes through the semi-circular coolers and is returned to the rotor and recirculated. Provision is made for ventilating the collector housing by circulating hydrogen through the housing by means of two pipes. Two dial thermometers indicate the temperatures of the ventilating gas before and after it passes through the cooler. If the temperature of the gas leaving the cooler exceeds 40 deg. cent., the thermometer rings an alarm. Indicating thermometers also ring an alarm if the bearing temperature exceeds 70 deg. cent.

VIII. Hydrogen Leakage

An automatic pressure regulating switch and valve maintain the hydrogen in the machine always slightly above atmospheric pressure to prevent air from leaking into the shell. The hydrogen pressure in the machine varies with its internal temperature. The average pressure is around ½ lb. per sq. in. and the leakage of the machine itself at this pressure is about 6 cu. ft. per day which costs around 10 cents. The hydrogen purity indicator wastes a small amount of hydrogen for its thermal analysis. Thus, the total hydrogen cost is very small, from 15 to 20 cents per day, depending upon how much is used by the hydrogen purity indicator.

IX. Increased Output

The excellent cooling properties of hydrogen enable a given machine to operate at an increased output at the same temperature rise. If the hydrogen pressure is increased above atmospheric pressure, the output can be further increased. Numerous heat runs were made in which the hydrogen pressure was increased in steps up to 25 lb. per sq. in. These tests indicated that a hydrogen pressure of 15 lb. per sq. in. gave the best results. If the pressure is increased above this amount, the windage loss increases appreciably and the gain in output is not so marked.

The following table shows how the output of salient-pole high-speed condensers increases with the same temperature rise when hydrogen is used for the cooling medium:

Cooling medium	Machine output
Air at atmospheric pressure	100 per cent
Hydrogen at a pressure slightly above atmospheric pressure	125 per cent
Hydrogen at a pressure of 15 lb. per sq. in. above atmospheric pressure	140 per cent

Naturally, these figures will vary with different types of machines. The field winding is usually the limiting feature because it is more difficult to ventilate, and magnetic saturation and stability impose more limitations on the rotor than on the stator.

X. Decreased Losses

The introduction of hydrogen into a machine reduces the rotor windage loss to about eight per cent of its loss in air. The following table shows the saving in windage loss of the two condensers:

Machine capacity kv-a.	Reduction of windage loss accomplished by hydrogen
20,000	85 kw. (0.42% of machine rating)
12,500	51 kw. (0.41% of machine rating)

The internal copper temperatures are less with hydrogen, and so the copper losses will be slightly reduced. Fig. 7 shows the total losses of the 20,000-kv-a., three-phase, 60-cycle, 11,500-volt hydrogen-ventilated condenser at various loads. The losses are given for air at atmospheric pressure, for hydrogen slightly above atmospheric pressure, and for hydrogen at 15 lb. per sq. in. At 20,000 kv-a. the total loss of this condenser in hydrogen is only 1.5 per cent.

XI. Cost of Outdoor Installation

The initial cost of any new type of apparatus is usually high, and the development of hydrogen-cooled machines has not yet reached the point where its cost alone is the same as that of a standard air-cooled machine of the same size. The gas-tight construction, the water coolers, and the auxiliary control features naturally increase the cost which is partly offset by the increased rating obtainable. However, the value of the improved efficiency due to the lower windage loss (Fig. 7) will probably prove the deciding factor in any cost comparison. The capitalized value of the two per cent losses of a synchronous condenser is about the same order of magnitude as the first cost of the condenser installation, so that any reduction in the losses is of the same economic value as an equal reduction in cost. Thus, when decreased losses, increased capacity, lower internal temperatures, reduced fire risk, longer insulation life, cleanliness, quietness, and saving in building expense (outdoor operation) are capitalized, a large hydrogen-ventilated machine has a real economic justification.

Conclusions

The results obtained on these two hydrogen-ventilated synchronous condensers to date have been very encouraging and three more machines, rated 15,000-kv-a., are under construction. Not only have the hydrogen features of the machines performed satisfactorily, but during the past winter the machines have operated successfully out of doors with no protection from the weather. Thus outdoor synchronous condensers, whether air or hydrogen cooled, should give reliable service at a reduced overhead expense.

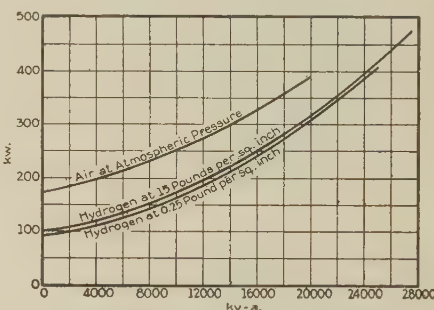

Fig. 7—Total Losses of the 20,000-Kv-a., 11,500-Volt, 60-Cycle. Hydrogen-Ventilated Synchronous Condenser

Electrical manufacturers are constantly striving to improve the efficiency and the ventilation of rotating machinery. High-grade magnetic steel, transposed armature windings, correct magnetic structure shapes and proportions, improved rotor fans and ventilating ducts, thinner and more compact insulation, etc., all tend to reduce the losses and the size of a machine. However, these refinements have been worked over so exhaustively that further improvements in performance characteristics by these means will perhaps be relatively small. Any appreciable gain must come by the way of a radical change in the machine structure, materials, or ventilating medium. Hydrogen cooling is one of these radical departures from tradition which opens new avenues of progress and rotating machines with 99 per cent efficiency may soon be a reality.

Acknowledgment

The cordial cooperation of the New England Power

Company and the Appalachian Electric Power Company in obtaining the various tests on these hydrogen-ventilated synchronous condensers is greatly appreciated.

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Abridgment of

A New Type of Hot Cathode Oscillograph its Application to the Automatic Recording of Lightning and Switching Surges

BY R. H. GEORGE*

Associate, A. I. E. E.

Synopsis.—*This paper presents a new general purpose type of hot cathode oscillograph which employs a new electrostatic method of focusing the beam. This oscillograph will operate at any beam potential from 500 to 20,000 volts or more, and at any gas pressure below 30 microns. High photographic sensitivity at medium voltages is attained by the use of a high-intensity beam.*

A portable form of the oscillograph for recording lightning surges on transmission lines is described, together with circuits by means of which the lightning surge automatically starts the beam in from ½ to ¼ microseconds after the surge voltage begins to rise from zero. This oscillograph was put into operation on one of the 140-kv. transmission lines of the Consumers Power Company of Jackson, Michigan, on August 27, 1928.

* * * * *

Introduction

With the interconnection of large power systems and with the rapid developments in the art of radio and carrier-current communication have come new problems, many of which involve the study of high-frequency phenomena beyond the range of the ordinary Duddell oscillograph. Consequently the importance of solving such problems has stimulated active interest in the development and application of the cathode ray oscillograph,† a device capable of recording extremely high frequency phenomena. As a result there have been developed within the last decade, some three or possibly four general types of cathode ray oscillographs as follows: the low voltage hot cathode type of the Western Electric Company,[1] the medium-voltage hot cathode type of Wood,[2] the high-voltage cold cathode type of Dnfour,[3] Norinder,[4] the General Electric Company,[5] and more recently the high-voltage hot cathode type of Rogowski.[6]

This paper presents a new general purpose type of hot cathode oscillograph, capable of operating at any potential from 500 volts to 20,000 volts or more, and a special portable form for lightning recording. The object in developing the general purpose oscillograph was to produce one having sufficient flexibility to combine so far as possible the desirable qualities of the previous types of cathode ray oscillograph and yet be simple and reliable in operation.

Salient Features of the New Oscillograph

Some of the outstanding features of the new oscillograph are as follows:

1. The use of a special hot cathode electron gun which makes possible automatic starting and stopping of the beam for recording lightning surges on transmission lines.

2. The use of a new electrostatic method of focusing the beam, effective at any pressure from about 30 microns down to the lowest pressure obtainable with a mercury pump.

3. The entire beam passes through the high-voltage anode, thus eliminating the problem of anode heating.

4. Bakelite is used for insulating the high-voltage cathode and the deflecting plates, thus reducing the danger of breakage.

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†For a history of the development of the cathode ray oscillograph with complete bibliography see "Measurements in Electrical Engineering by Means of Cathode Rays," by J. T. MacGregor-Morris and R. Mines, *Journal of I. E. E.*, Nov., 1925, Vol. 63, p. 1056.

1. See Bibliography.

Presented at the Regional Meeting of the Middle Eastern District, Cincinnati, Ohio, March 20-22, 1929. Complete copies upon request.

5. The deflecting plates are adjustable from outside the vacuum which makes it possible to vary the deflection sensitivity if desired.

6. All parts are readily accessible and easily replaced in case of damage.

General. The method of attack in the design and development of the general purpose oscillograph has been to gain the necessary photographic sensitivity through the use of a high-intensity beam at a minimum beam voltage. The principal problem, then, has been one of devising satisfactory means for producing and focusing a high-intensity beam over a sufficient range of beam voltages to insure the necessary photographic sensitivity. It is the solution of this problem which constitutes the major contribution of this paper.

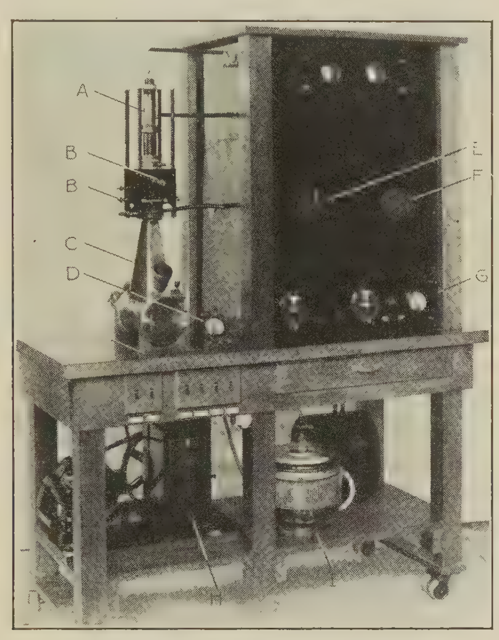

FIG. 1—PORTABLE HOT CATHODE OSCILLOGRAPH FOR SURGE RECORDING

A Electron gun housing.
B. Terminals of deflecting plates.
C. Oscillograph bell.
D. Vacuum gage.
E. Gun voltage control.
F. Cathode voltage control.
G. Timing oscillator.
H Vacuum pump.
I. Drying chamber for films.

Description of the Oscillograph. A general idea of the appearance of the oscillograph may be gained from Fig. 1, which shows a portable outfit designed especially for recording lightning surges. Fig. 2 illustrates the internal construction.

The general purpose laboratory type of instrument is provided with both a rotating film drum and plate drum. The film drum takes 5 in. by 30 in. with which the equivalent of a continuous record 140 in. in length can be obtained. The plate holder takes six 4- by 5-in. plates. The portable type shown in Figs. 1 and 2 is made much more compact to reduce the volume, and takes 5-in. roll film. The oscillograms are 2½ in. by 5 in., although in a more recent design the oscillograms will be 3½ in. by 5 in. If special long rolls are used, as many as 100 exposures can be taken with one loading.

The Electrostatic Method of Focusing the Beam. The most important feature of the oscillograph illustrated is the electrostatic method of concentrating and focusing the beam, which is effective at any beam potential from 500 volts to a least 20,000 volts.

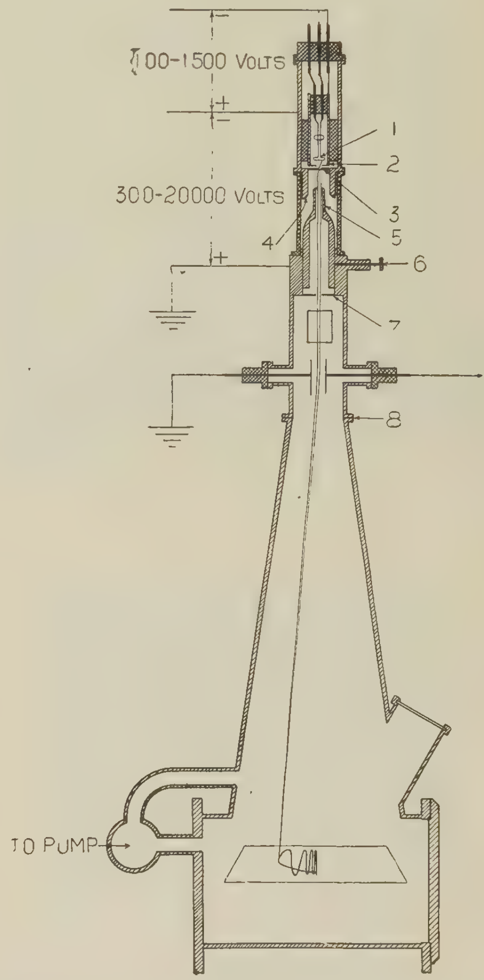

FIG. 2—DIAGRAMATIC SCHEME OF THE PORTABLE OSCILLOGRAPH

(1) Ribbon filament.
(2) Filament shield.
(3) Positive plate.
(4) Cup-shaped cathode.
(5) Cylindrical anode.
(6) Screw for raising and lowering anode.

Referring to Fig. 3, the beam from the filament (1) is concentrated and brought to a focus at the hole in the plate (3), by properly proportioning the spacing between the filament (1), the filament shield (2), and the plate (3), with respect to the size of the hole in (2), to produce a rapidly converging field between the filament and plate. After passing through the small hole in the plate into the high potential cathode (4) the beam diverges at first as indicated by the dotted lines,

Fig. 3, due to the momentum received from the converging field in the gun.

The cathode (4) and the anode (5) are so shaped that the high-potential field converges toward the anode. Therefore the electrons in falling through this field are not only accelerated in the direction of the anode but are given a component of velocity toward the center of the beam. If this inward radial component of momentum of the electrons is great enough to overcome their force of repulsion, the beam can be brought to a focus. It is therefore apparent that the distance from the cathode at which the beam will come to a focus depends upon the diameter of the beam when it starts to converge, hence the divergence of the beam on

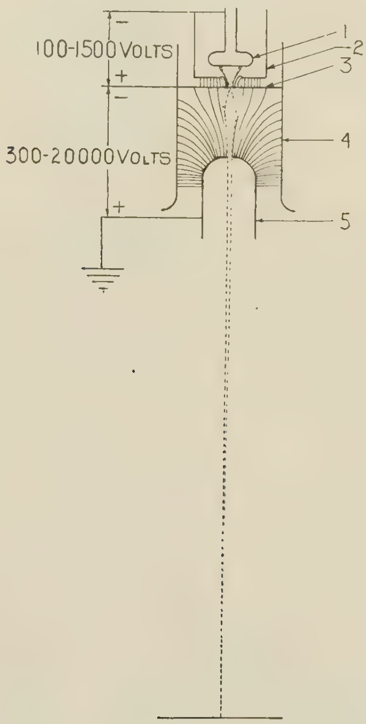

Fig. 3—Diagram Showing Method of Focusing the Beam

entering the cathode. This fact also necessitates the use of a large hole in the anode.

Since the time through which the mutual repulsion of the electrons in the beam acts, depends upon the velocity of the beam and consequently upon the beam potential, it is necessary to be able to vary the radial component of the high potential field in order to focus the beam. This is done by raising or lowering the anode by means of a rack and pinion operated by the knurled head (6), Fig. 2.

Application of the Oscillograph

A. With Continuous Beam.

A steady beam can be produced and maintained for hours, if necessary, at any beam voltage from 500 volts to 20,000 volts, depending upon the deflectional and photographic sensitivities required.

The continuous beam permits study of the various forms of Lissajous figures, such as power-loss loops including magnetization and dielectric loss curves, vacuum tube characteristics, frequency checking, etc.

Fig. 4 represents a section of a voice record taken with the laboratory oscillograph at a beam voltage of approximately 2500 volts. The timing is indicated by the

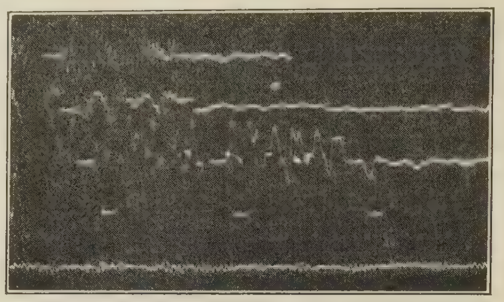

Fig. 4—Voice Record Taken with 2500-Volt Beam

dashes which occur at intervals of 1/60 of a second. The diameter of the beam was less than 1/2 millimeter.

Fig. 5 is a 500,000-cycle wave having an amplitude such that the beam was traveling at the rate of 100 kilometers (62 mi.) per second when crossing the zero axis. This oscillogram was taken with a 10,000-volt beam.

B. Recording Lightning Surges on Transmission Lines.

It was at the request of the Consumers Power Company of Jackson, Michigan that the writer, under the auspices of the Engineering Experiment Station of Purdue University, undertook the design of a cathode ray oscillograph for recording lightning surges on transmission lines. This cooperative project resulted in the construction of the portable oscillograph illustrated by Fig. 1.

The recording of lightning surges presents a difficult

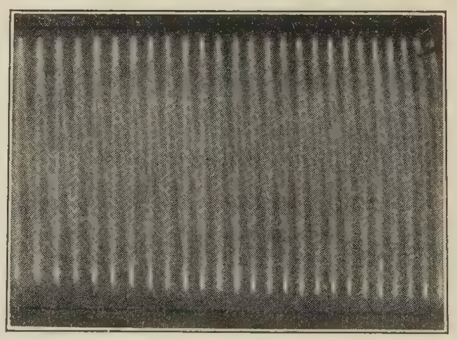

Fig. 6—500,000-Cycle Wave Taken with 10,000-Volt Beam

problem, in that the time at which a surge will occur cannot be predetermined. Therefore the oscillograph beam must either remain on continuously, or means must be provided whereby the transient to be recorded automatically starts the beam.

Fig. 5 represents the circuit diagram for the portable oscillograph including a circuit for automatically initiating the beam by applying plate voltage to the

electron gun. With this circuit the plate or beam current of the electron gun must pass through one of the two vacuum tubes inserted between the gun voltage supply and the filament. Therefore the beam can be stopped by applying a sufficient negative bias to the grid of the vacuum tubes to prevent the flow of plate current. Then in order to initiate the beam, it is necessary to apply a small positive impulse to the grid of one or both tubes, after which the time required for the beam to build up depends upon the rate at which the electron gun can be charged as a condenser.

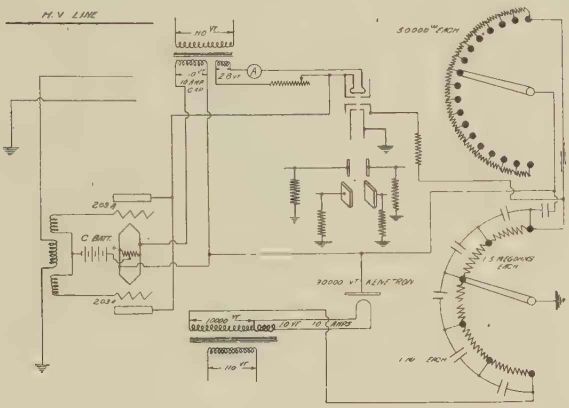

FIG. 7—CIRCUIT FOR AUTOMATICALLY STARTING BEAM BY SWITCHING PLATE VOLTAGE OF ELECTRON GUN

The circuit for producing the positive impulse on the grid of one of the vacuum tubes has some desirable characteristics which may not be evident. The first important requirement to be met is that the surge to be recorded must produce a positive impulse on the grid of one of the tubes regardless of the polarity of the surge. This is most readily accomplished by an inductively coupled circuit which also has the advantage that the antenna of the dividing condenser can be insulated from the high-voltage direct current of the oscillograph.

FIG. 11—LIGHTNING GENERATOR IMPULSE WHICH AUTOMATICALLY STARTED BEAM

A rather unexpected advantage of the inductively coupled circuit comes from making the inductance such that the inductive reactance of the antenna circuit is small compared to the capacity reactance. This permits the charging current in the antenna circuit to reach its maximum well in advance of the maximum voltage of the surge, and since the voltage drop across the inductance is proportional to the rate of change of current, it therefore reaches its maximum ahead of the current. The inductance is, however, the primary of an air-core transformer, therefore the voltage induced in the secondary or grid circuit also reaches its maximum ahead of the current in the primary.

FIG. 12—INSTALLATION OF CATHODE RAY OSCILLOGRAPH ON 140-KV. LINE OF THE CONSUMERS POWER COMPANY

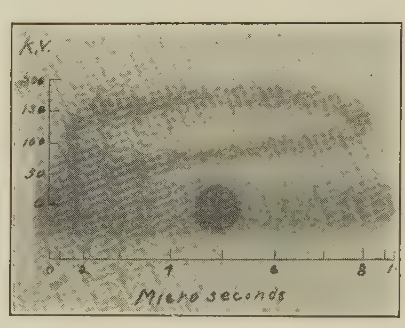

FIG. 13—LIGHTNING SURGE RECORDED ON 140-KV. LINE OF THE CONSUMERS POWER COMPANY

Since klydonograph records indicate that lightning surges may reach a maximum in from one to ten microseconds, this circuit is capable of getting the beam under way in time to record practically the entire wave.

Fig. 11 shows a record taken of a lightning generator wave in which the beam was automatically started by the surge. The surge was applied at right angles to a 50,000-cycle timing wave.

The portable hot cathode oscillograph, (Fig. 1), employing the automatic beam starting feature, was put into operation on a 140-kv. line of the Consumers Power Company of Jackson, Michigan at their Blackstone Substation on August 27, 1928. Fig. 12 shows this installation.

This oscillograph is entirely self-contained with the

exception of the power supply which is taken from a 110-volt 60-cycle source.

With well dried film the oil pump alone will produce a workable vacuum in approximately three minutes. The film holder is daylight loading and takes a standard No. 104 film.

Fig. 13 shows a 170-kv. surge which occurred during a distant lightning storm.

Development work is being continued along the following lines:

1. Further increasing the beam intensity.
2. Focusing still higher voltage beams.
3. The production of a linear time axis for lightning records.
4. Making the recording of lightning surges more nearly automatic.

Conclusion

It is felt that this oscillograph will prove particularly useful in laboratories where a wide variety of work is handled as well as in field investigations.

The author wishes to express his sincere appreciation to Professor C. Francis Harding for his continued interest and encouragement as well as making the work possible, to Mr. J. W. Raleigh for valuable assistance in the early stages of the work, and to Mr. J. R. Eaton of the Consumers Power Company for many valuable suggestions.

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Abridgment of

Telephone Circuits for Program Transmission

BY F. A. COWAN[1]
Member, A. I. E. E.

Synopsis.—Networks of telephone circuits which are extensively used in the transmission of programs to broadcasting stations are described in this paper. Certain stages in the development of these networks are considered and the general requirements for satisfactory transmission at the present time are enumerated. The arrangements of the networks as well as the procedures used in setting up and maintaining them are discussed.

* * * * *

Much of the phenomenal growth and present excellence of radio broadcasting has resulted from contributions made by associated branches of the electrical art. Of these contributions perhaps none has had a greater effect than the introduction of the program transmission wire networks, which make chain broadcasting possible. Broadcasting had hardly emerged from the novelty stage before the need for programs presenting music of the highest grade, speeches by prominent people, and descriptions of sports events of sectional or national interest became evident. It was further recognized that in addition to providing programs of this character, it would be desirable to broadcast the programs simultaneously from a number of stations. These conditions established a demand for means of picking up selected program material and transmitting it to broadcasting stations scattered throughout the country. For this transmission, wire lines have proved to be very satisfactory and are in general use for this purpose.

Prior to the general development of radio broadcasting, the Bell System had, incident to other developments, worked out the problems involved in such transmission, and on numerous occasions had set up interconnections of radio telephone stations and public address systems which were substantially the same as those required for broadcast program transmission. The telephone companies, therefore, were able to meet this new requirement for communication service early in the development of radio broadcasting. One of the first occasions of this type was in the fall of 1922, when the description of the Chicago-Princeton football game at Chicago was broadcast through station WEAF, then operated by the American Telephone and Telegraph Company, at New York City. Another of the earlier services was the interconnection of six broadcasting stations, one of which was in Dallas, for the simultaneous broadcasting of President Coolidge's first address to Congress on December 6, 1923. Since that time there has been a steady and continuing growth in this service until there are now furnished by the Bell System more than 30,000 mi. of regularly established program circuits which connect in various combinations and at various times over 125 radio broadcasting stations covering the entire United States. The various stages of this development up to the establishment of a 15 station part-time network in the latter part of 1924 are described in a paper by Messrs. Foland and Rose, published in the January 1925 issue of *Electrical Communications*.

1. Long Lines Dept., American Telephone and Telegraph Co., New York, N. Y.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

The first multi-station network for which special equipment was provided at key points on a permanent basis was initially called the "red network" for no other reason than that those cities which were to be connected were indicated on a chart by red lines, and a memorandum on the arrangements for the circuits referred to them as the "network shown in red." As other networks came into being, the convenience of a short color name for differentiating between them resulted in a rather general use of this form of designation within the telephone companies, and it was not long before this nomenclature had spread among the various broadcasting companies.

Initially, this network service was confined mainly to evening hours and to sections where telephone message circuits could be obtained, but it soon became apparent that more time would be required than could be furnished on this basis, and as rapidly as possible, program circuits specially provided for this purpose were made available on a larger scale. The routes of the regularly established program circuits of the Bell System in the United States on March 15, 1929, are shown on Fig. 1. These regular networks are supplemented by special circuits which are established for the transmission to the network control points of programs picked up at the location of event of particular interest or national importance. Also, on certain occasions, several of the chains have been merged into one, thereby forming a network of stations which effectively makes the United States into one large auditorium.

The general transmission requirements of circuits for the satisfactory handling of program material are not greatly different from those for good telephone connections. The nature of the program material is usually such, however, that the specific requirements for a network of program circuits are much more exacting than for the usual types of message circuits.

These differences lie in the fact that for satisfactory transmission of speech from the message traffic standpoint the primary requisite is that the message shall be readily recognizable and intelligible with naturalness of tones as an important but secondary consideration; whereas the satisfactory transmission of programs for broadcasting purposes requires faithfulness of reproduction of speech, music and incidental details with intelligibility and naturalness of tone of about equal importance. In order to achieve these effects it is necessary to transmit with reasonable uniformity a wider range of frequencies and volumes than is ordinarily required for message traffic.

For example, if properly utilized a frequency band 2500 cycles in width will provide facilities for the transmission and ready interchange of ideas through the agency of easily understandable speech, whereas for program transmission with the present type of microphones, amplifiers, and loud speakers, a frequency band of between 4000 and 5000 cycles in width is usually

FIG. 1—BELL SYSETM PROGRAM NETWORKS IN THE UNITED STATES ON MARCH 15, 1929

Network	No. of stations	Length in miles
Red — NBC	44	10,800
Blue — NBC	11	3,500
Purple — CBC	42	7,500
Green — ABC	3	1,900
Pink — ABC	5	1,700
Orange — NBC	5	1,700
White — PPA	21	3,800
Brown — DL	3	450
	134	31,350

required. Most program circuits at the present time transmit frequencies above about 100 cycles and below about 5000 cycles. The normal range of volumes in programs is usually much larger than can be successfully handled by the present type of radio broadcast transmitters and receivers with the result that at the pickup point the amplification is adjusted from time to time to reduce the variations in volume. This compression is such that for average broadcast material the momentary volume peaks vary over a range of 20 to 30 decibels. The program transmission circuits are arranged to transmit satisfactory volume ranges of this order of magnitude. Since much of the character of large symphony orchestras is contributed by variations in volume, it would undoubtedly add greatly to the pleasure afforded the radio listener to reproduce these variations even more faithfully. It is to be expected, therefore, that within the next few years improvements in the broadcasting technique will be considered from various points of view and the network circuits will be called upon to keep pace with such developments.

with means of rapid intercommunication. To increase the effectiveness of this organization the country has been divided into areas with one of the wire centers listed above designated as the control office for the contiguous area. Telegraph wires are provided connecting each of the repeater offices within a given area with the area control point and the area control offices are in turn connected with New York. By the use of these telegraph wires the reports covering the condition of the circuits and instructions regarding measurements and adjustments required in setting up or rearranging the program circuits are handled. Due to the method used in connecting the branches to the trunk circuits, the various area control offices are able to carry on their work practically independently of the other offices.

To facilitate further the testing and maintenance of the network, the circuits within an area are further subdivided into sections usually about 500 mi. in length. Certain offices are selected and designated as control points for these sections which are known as program circuit units and are established, tested and maintained as independent units. The units are designated by the

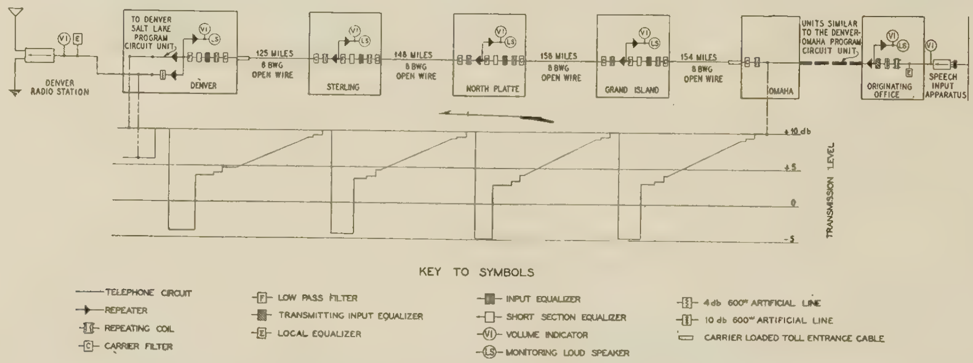

Fig. 2—Schematic Layout and Transmission Level Diagram of Denver-Omaha Program Circuit Unit Arranged For Transmission from Omaha to Denver

The wire networks are arranged for the transmission in only one direction in the same manner as the broadcasting stations. This removes the problem of echoes and possible singing which is introduced where two-way transmission is required. It also permits a more simple treatment of the many connections between circuits involved in supplying programs to a large number of points. The networks are set up with main radial circuits over trunk routes from which branches feeding the various stations are taken off. At these branch points the connection is accomplished with the aid of a one-way amplifier arranged to prevent any reaction on the trunk circuit by conditions on the branch circuit.

New York City is the originating point of the red, blue, purple, and white networks and from it the largest number of wire networks radiates. Atlanta, Cincinnati, Kansas City, Chicago, St. Louis, and San Francisco are also large network centers. The work of properly setting up the veritable web of circuits radiating from and interconnecting these points and properly safeguarding the service, requires the constant attention of a large group of men strategically located and provided

names of the two terminal offices and those between the same two points are numbered successively. Complete networks are established by connecting the necessary number of units together. Any two program circuit units over the same route are so designed as to be interchangeable and a spare unit established for emergency or special use may be used to protect the service on several networks.

To illustrate the factors entering into the determination of the proper set up of a circuit unit, the layout of the No. 1 Denver-Omaha program transmission circuit unit which is a typical one, as well as the transmission levels at the various repeater offices, when arranged for transmission Omaha to Denver, is shown in schematic form in Fig. 2. It may be seen from this chart that the unit is so set up that the gain at each amplifier point just equals the loss in the preceding sections. This results in a uniform level at the output of each amplifier and permits the transmission of the program at a higher average volume level without overloading the amplifiers or introducing interference into adjacent circuits. At each amplifier point there is, in addition

to the amplifier transmitting towards the next station, one which is used for monitoring the circuits and making various service observations. An instrument known as a volume indicator is normally connected to this amplifier and is used to check up on the volume of the transmitted program. It is also used sometimes to obtain a quick check of the strength of tones applied for measuring purposes although there is provided for this purpose special precision transmission measuring apparatus.

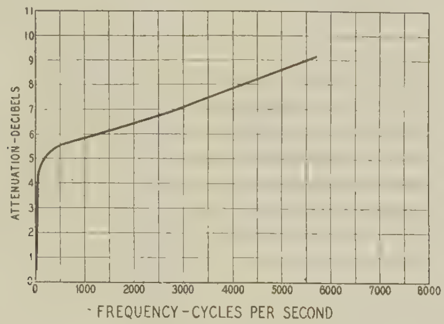

Fig. 3—Line Attenuation of Typical Repeater Section of a Program Transmission Circuit

The line wires in this case are No. 8 B. w. g. copper, and are not loaded, which is the type generally used for program transmission. The incidental cables for entrance into cities are either No. 10 or No. 13 B. & S. gage and are loaded to have approximately the same characteristic impedance as the line wires; namely, 600 ohms. The cut-off frequency of this cable loading is sufficiently high to permit the operation of the carrier current telephone systems which are connected to these wires. The transmission loss at various frequencies of a typical section of line wires with incidental cables is shown in Fig. 3. The over-all gain at various frequencies introduced at typical repeater points is shown in Fig. 4. It may be seen that within the band which at the present stage of the art the circuits are designed to transmit, the gain is substantially complementary to the loss so that the resultant net loss in each repeater section for the frequencies within this band is practically uniform. The gain of the repeaters at the higher and lower frequencies relative to 1000 cycles is adjustable so that it may be made to conform to the varying conditions likely to be encountered.

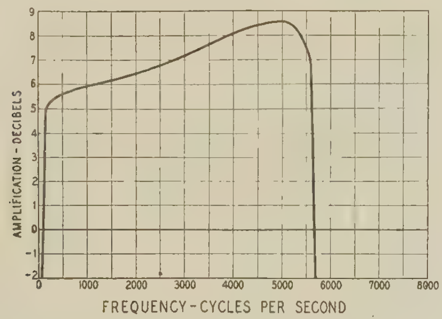

Fig. 4—Over-All Amplification of a Typical Repeater Office on a Program Transmission Circuit

In addition to the constant watch which is maintained through the length of the circuit, and particularly at all points where broadcasting stations are connected to the circuits during the transmission of programs, frequent tests are required in order to keep the circuits in shape and prepare them for the periods of use. At the present time complete measurements are made on each program circuit at least once each day, and periodic test of a less comprehensive nature are made at frequent intervals throughout the day. On the complete over-all tests, a testing tone of the required strength and having a frequency of 1000 cycles per sec. is applied at the originating point of the section of network under test. At each amplifier point in succession beginning with the originating point the level of the testing current is measured and reported back to the control office. Such changes as are necessary to bring the level to the required valued are made and when all points have been covered the frequency of the testing tone is changed and the procedure repeated. In general, measurements are made at only about four or five frequencies covering the band which it is desired to transmit on the daily tests although in some cases it may prove desirable to measure at as many as forty different frequencies. After completing the adjustments at all necessary frequencies the testing tone is removed and the circuit is observed for any noise, crosstalk or other possible sources of trouble. A test program is then sent over the circuits and reports as to quality are made. To provide for making this last test, the more important control offices are equipped with a high-quality phonograph pickup as well as microphones for talking tests.

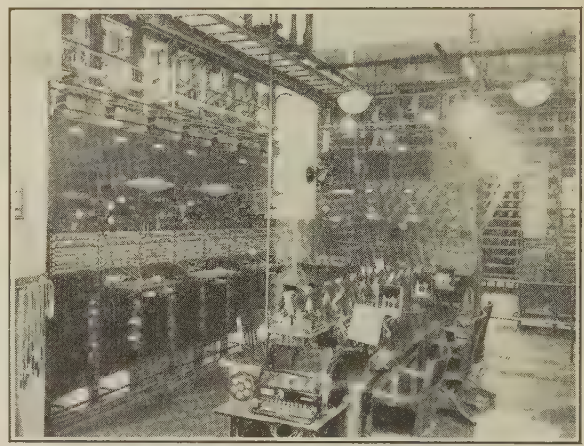

Fig. 5—Part of Equipment at New York for Program Transmission

Another condition which requires careful coordination on the part of the repeater and control offices is the practise of splitting a network at a specified time to provide for the transmission of one program to a certain group of the network radio stations while the remainder receive programs from a different source. These re-

arrangements may involve the creation of a new point as the temporary originating center, or switching a branch of a network feeding one or more stations from one network to another. Program orders are obtained daily from the broadcasting companies to cover the network set up required for each day's program and these orders are transmitted from New York to the area control office using telephone typewriters. The switches necessary for these rearrangements are then made under the directions of the area control offices.

In the installation of the equipment at repeater stations and distributing centers, care is taken to arrange the circuits so as to provide as great freedom from interruption as practicable and permit the quick rearrangement of circuits which may become necessary during emergencies. The repeaters and associated equipment are grouped together with the telegraph wire terminations and this unit is usually located in a separate room. An example of a part of the equipment arrangements at New York which is typical of the larger wire centers, is shown in Fig. 5.

The foregoing discussion has considered program transmission networks as they are today. At this time any attempt to predict the future course of development would probably require rather extensive recasting at some subsequent time. It seems fairly certain, however, that there will be continual improvements in the general broadcasting art and this factor is kept constantly in mind in the design of telephone circuits for program transmission in the future.

Abridgment of

Lightning Studies of Transformers by the Cathode Ray Oscillograph

BY F. F. BRAND[1]
Member, A. I. E. E.

and

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Associate, A. I. E. E.

Synopsis.—*Study of transformers has been under way for some time to coordinate the strength of transformers and transmission-line insulation under lightning conditions. This study has taken two forms; first, the transient dielectric strength of the line end of the winding and second, the distribution of transient voltages and therefore the stress caused by them throughout the winding.*

Theoretical studies and spark-gap tests of transient voltage distribution in transformer windings have been previously published by the Institute. Since then an extensive study of transient voltage phenomena has been made by the cathode ray oscillograph on power transformers connected to a short transmission line and subjected to artificial lightning waves sent along the line.

The effects of the transmission line, concentrated inductance, and transformer entrance bushings on traveling waves were studied, as well as the effect of traveling waves of various service conditions in producting internal oscillations in ordinary transformers:

The non-resonating transformer was studied under similar conditions.

A striking agreement between the oscillographic records and theoretical conclusions previously published was found, sufficient to establish beyond any doubt the following conclusions:

1. Very high-voltage oscillations occur throughout the entire winding of even a grounded neutral transformer.

2. Points of the winding near the grounded neutral may rise to 95 per cent of the crest voltage of a very short traveling wave (three microseconds long).

3. Entrance bushings have a negligible effect on the shape of the incoming traveling wave.

4. In case of sudden voltage changes, concentrated inductance in series with the transformer, unless by-passed by a suitable device, causes rise of voltage across the transformer terminals as well as internally in the windings.

5. Arc-over of line insulators by a traveling wave produces severe oscillations in a transformer the amplitudes of which are roughly proportional to the arc-over voltage of the line insulators.

6. Grading the insulation between high voltage and low voltage and ground in ordinary transformers with grounded neutral is a dangerous practise when the transformers are subject to lightning.

7. All the above conclusions apply to concentric winding core type as well as interleaved and shell type transformers. From theoretical studies the non-resonating type of transformer has been developed and its action checked by tests. This type of transformer eliminates voltage oscillation within the winding and therefore local concentration of transient voltage.

An Appendix entitled Present Status of the Cathode Ray Oscillograph on the Measurements of Transients, by H. L. Rorden and J. C. Dowell, both of the General Electric Company, Pittsfield, Mass. is included in the complete paper.

Introduction

Part I

TRANSFORMERS are, in general, reliable pieces of apparatus; in fact, their reliability is probably higher than that of any other electrical apparatus, but a small percentage of failures does take place and the majority of these is probably due to lightning.

The effect on transformers of high-frequency oscillations and steep-front waves are to some extent similar, and a discussion of the effects of lightning in a measure covers the effects of other high-voltage transients.

Part II

Lightning Failures of Transformers

Transformer failures sometimes occur directly through the major insulation from high-voltage winding to low voltage or ground, either near the terminal or in the main body of the winding.

Failures are more liable to occur between turns or

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1. Both of the General Electric Company, Pittsfield, Mass. Appendix.

Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

coils of the same winding or in auxiliary parts connected to the winding, such as taps, tap terminal boards, or ratio adjusters.

Failures which occur through the major insulation near the line terminal are due to excessive voltage applied to the transformer.

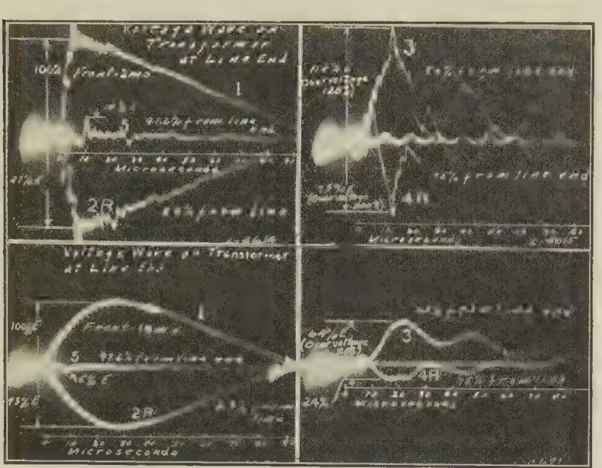

Fig. 6—Effect of Front of Traveling Wave. 6600-Kv-a. Transformer

Top

"Exceedingly steep front" and long tail

1. Voltage across transformer

2, 3, 4 and 5 are voltages to ground at points 97.2, 50, 25, 2.8 per cent away from ground terminal with crest values of 97, 114, 75, and 18 per cent of applied voltage, respectively

Bottom

"Steep front" and long tail

1. Voltage across transformer

2, 3, 4, and 5 are voltages to ground at 97.2, 50, 25 and 2.8 per cent away from ground end with crest values of 93, 64, 24 and 5 per cent of applied voltage

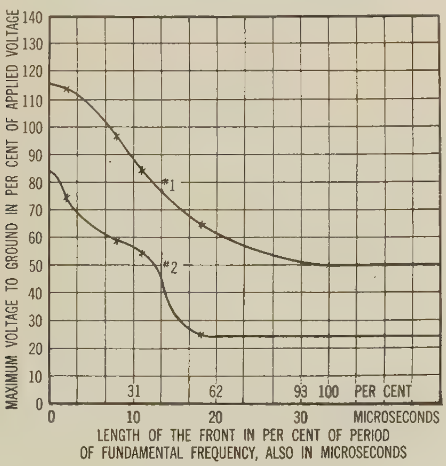

Fig. 7—Effect of Steepness of Front of the Traveling Wave on Voltage to Ground (Test)

1. Point of winding 50 per cent away from ground terminal
2. Point of winding 25 per cent away from the ground terminal

Failures occurring internally in the winding or auxiliary parts are due not only to the voltage to which the transformer is subjected but to the nature of the surge and its effect in the transformer.

It is obvious that irrespective of what might be called the internal effect of the surge on the transformer, some limit must be set to the voltage which may be applied to the transformer. If this is not done failure will occur in any transformer.

Part III

Limits of Voltage on Transformer Insulation

The voltage required to cause breakdown by lightning is higher the greater the energy required for a particular

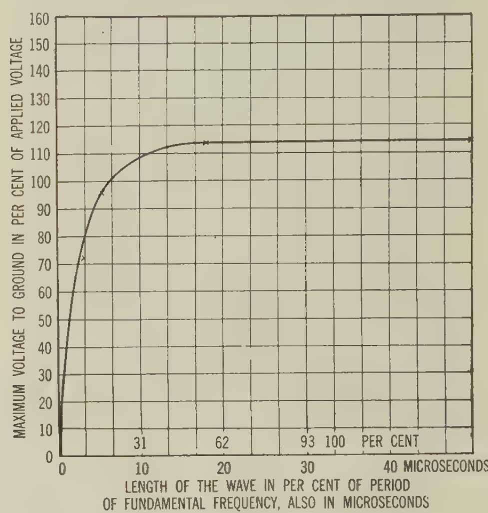

Fig. 8—Effect of the Length of Traveling Wave on Voltage to Ground of Point of Winding 50 Per Cent Away From Ground Terminal (Test)

kind of insulation. It is fortunate that the oil and most solid insulations require greater energy to cause breakdown than air, and therefore higher lightning voltage for the same 60-cycle strength.

To determine the lightning breakdown voltage of

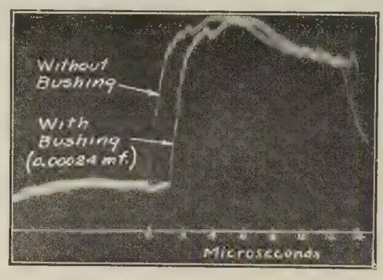

Fig. 10—Effect of Bushing on Shape of Traveling Wave

(To avoid confusion two waves were displaced along time coordinate as shown)

even the simplest insulation structure, requires a knowledge of the wave form of the applied voltage.

When lightning sparkover of insulators is referred to it is usually based on data published by F. W. Peek, on the insulator sparkover under artificial lightning produced in the Pittsfield Laboratory.

Based on this wave form, a string of suspension insulators requires a voltage of approximately 1.8 to 2.0 times the 60-cycle dry sparkover voltage to cause

lightning sparkover. Sparkovers caused by natural lightning have given the same range.

Corrugated or petticoated bushings such as are used for outdoor service require a lightning voltage from 2.0 to 2.5 times the 60-cycle dry sparkover voltage depending upon design.

Oil and other solid fibrous insulation such as that used in oil-immersed transformers require from 2.8 to 3.5 times the lightning voltage compared to 60-cycle one-minute breakdown voltage. These ratios are crest-to-crest value.

This ratio does not hold good for the ratio of standard factory test voltage to 60 cycles to the breakdown value under lightning of completed transformers due to two causes:

1. The completed transformer has a margin of safety over the factory test. This margin varies with voltage rating, being usually higher in the lower rated voltage apparatus.

2. The ratio holds for a simple insulation test piece and does not take into account the essential difference between the voltage distribution along a winding at low (that of Standard Insulation Test) and high (that of surges met in service) frequencies.

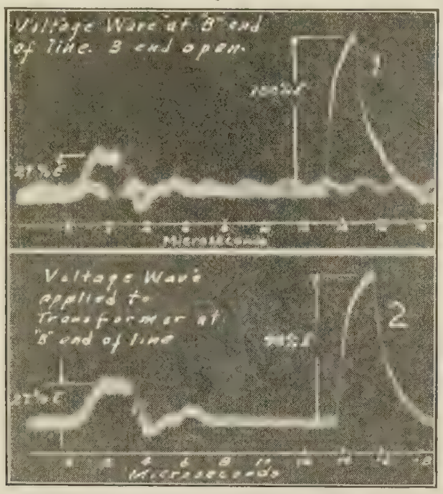

Fig. 11—Effect of Transformer on Incoming Traveling Wave

1. Wave at the end of transmission line with transformer disconnected
2. Wave at the end of transmission line with transformer connected (voltage across transformer)

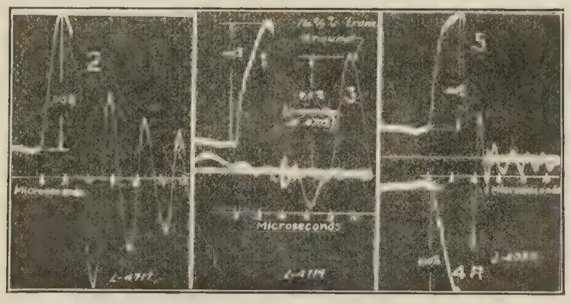

Fig. 12—Effect of Series Inductance in Case of Traveling Wave of Very Steep Front and Tail

A Inductance of 1.0 μ h.
1. Voltage applied across transformer and inductance in series
2. Voltage across transformer. Crest value 115 per cent of the applied wave (Curve No. 1). Frequency of oscillation 333 kilocycles
3. Voltage to ground at point of winding 17 per cent away from the grounded end. Crest value 95 per cent of applied voltage

Note, front of the wave No. 2 is steeper than No. 1. Approximate effective capacitance of the transformer winding 0.00206 μ f.

B. Inductance of 0.24 μ h.
4*R*. Voltage applied across inductance and transformer
5. Voltage across transformer. Crest value 100 per cent of the applied voltage. Frequency 710 kilocycles. Note, front of the wave No. 5 the same as No. 4*R*. Approximate effective capacitance of the transformer winding 0.0019 μ f.

Parts IV and V

Parts IV and V of the original paper deal in a non-mathematical way with the laws governing the behavior of a transformer under high-frequency excitation

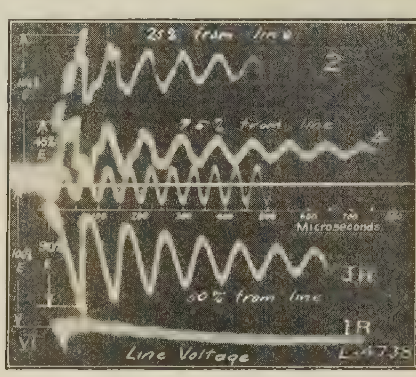

Fig. 13—Effect of Transformer Losses on Damping of Transient Voltages

Oscillations of shell type transformer caused by long traveling wave of eight microseconds front
1*R*. Applied voltage
2, 3*R*, 4. Voltages at points 75 per cent, 50, and 25 per cent away from ground end, with crest values of 106 per cent, 90 and 45 per cent

Part VI

Tests by Cathode Ray Oscillograph

In order to check previous theoretical studies of the behavior of transformers under lightning, and tests made by spark-gap measurements, a series of tests by an artificial lightning generator in connection with a short transmission line has been made by the cathode ray oscillograph.

Where convenient several oscillograms were recorded on the same film. In such cases some waves were taken above the zero line, then the polarity of the oscillograph was reversed and the remainder of the waves recorded downward below the zero line. The waves obtained with reversed polarity are marked *R*. The crest value of the wave at the transformer end of the line (see Fig. 20) was considered as unity and crest values of all other waves expressed in per cent of this value.

The voltage of any given point of the winding to ground is considered "normal" if it is the same percentage of the crest of the applied wave as it is under normal operating frequency excitation. Excess over

this value is called "overvoltage" and is expressed in per cent of the "normal" voltage.

The tests were made on an overhead transmission line over two miles long having a surge impedance of

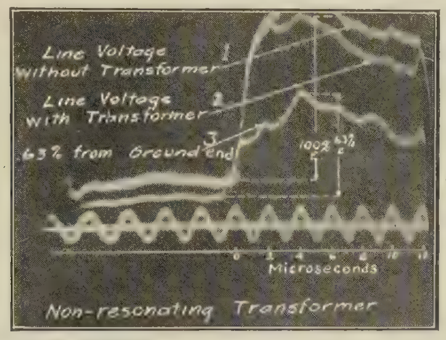

Fig. 14—Non-Resonating Transformer

1. Voltage wave at the end of transmission line with transformer disconnected
2. Voltage wave at the end of the transmission line with transformer connected (voltage across transformer)
3. Voltage at 63 per cent point. Crest value 63 per cent of applied voltage

Note No. 3 a practical duplicate of the shape of No. 2 in spite of the fact that the transformer was out of oil and electrostatic unbalance was created thereby

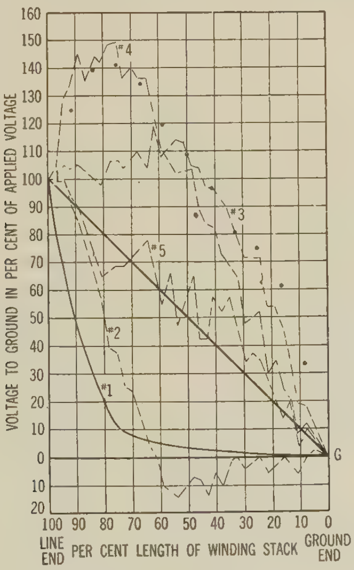

Fig. 15—Simultaneous Voltage to Ground Produced by a Single Traveling Wave (Test)

1. At the instant of impact ("initial" voltage distribution)
2, 3, 4, and 5.—3, 14, 18 and 24 microseconds later respectively

Dots show results of calculation (same as curve 3, Fig. 2) of maximum voltage to ground

350 ohms. The following apparatus was used at various times in the tests:

6600-kv-a. 110-kv. circular coil type transformer

1000-kv-a. 44-kv. shell type transformer

Air-core inductances of 1.0 amd 0.24 millihenry

110-kv. solid insulation transformer bushing having a capacitance of 0.00024 microfarads.

Various protective spark-gaps with and without resistance in series.

To date more than 600 records have been obtained representing a very wide range of service conditions affecting the voltage transients.

The agreement between theoretical predictions[4] and experimental results is striking.

In the original paper, general laws are stated covering the effect on transformer oscillations of the front, length, and tail of a traveling wave; also of entrance bushing and the concentrated inductance (like reactors, current transformers, etc.).

Effect of Inductance in Series with Transformer

Inductances, such as current-limiting reactor or current transformer, if not bridged by a proper by-pass device, enter into oscillation with the effective capacity of a transformer to which they are connected where struck by traveling wave.

Such oscillations may create very severe overvoltage

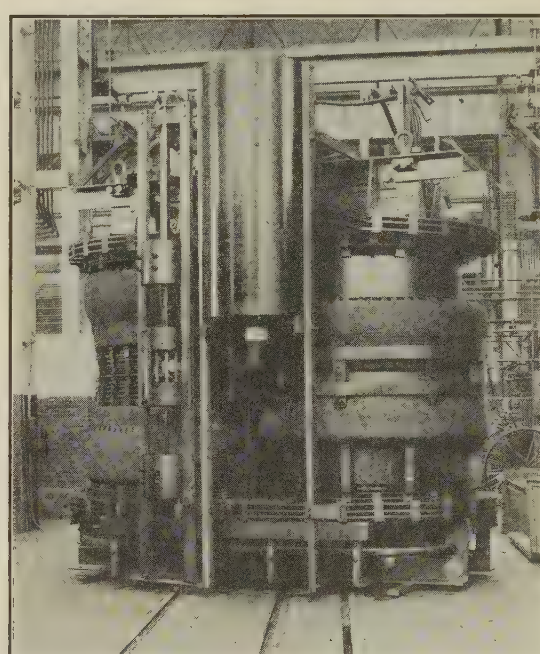

Fig. 18—220 Kv.- and 37,000-Kv-a. (Equivalent Capacity) Three Winding Non-Resonating Transformer

500-kv. insulation test

inside of the transformer and cause voltage across the transformer in excess of the crest value of the incoming wave. These oscillations also take place in case of arcing grounds or switching.

Inductances of much smaller values have negligible effect on incoming wave but also enter into oscillation. overstressing the line end of the transformer winding,

4. See *Effect of Transient Voltage on Power Transformer Design*, by K. K. Palueff, A. I. E. E. Quarterly Trans., Vol. 48, April, 1929.

Part VIII

The Non-Resonating Transformer

The reason that the voltage distribution in a transformer under surges is not uniform and that oscillations take place may be briefly stated to be:

Because the electrostatic charging current of the ordinary transformer has to flow through the winding.

If the electrostatic charging current is directly supplied to the various parts of the winding in the proper proportion, then unequal voltage distribution and oscillations will be eliminated.

This principle is the basis of design of the non-resonating type of transformer. At the present time in commercial designs, it is limited to transformers operating with neutral grounded directly or through a moderate impedance.

Thus by properly proportioning the electrostatic characteristic of the transformer, the voltage distribution throughout the winding is made a straight line falling from line terminal to ground, irrespective of the frequency or wave shape of the applied voltage.

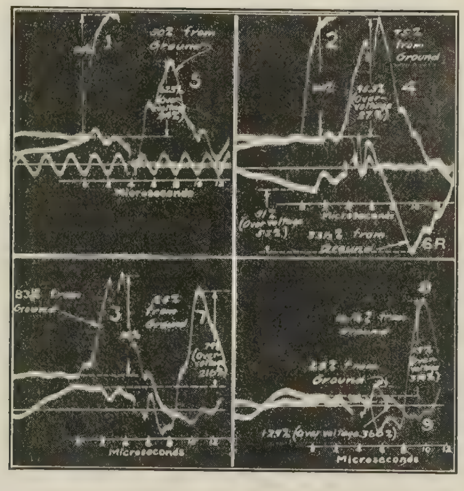

Fig. 21—Oscillations Along Winding Due to Short Traveling Wave of "Exceedingly Steep" Tail, Produced by Sparkover of Line Insulator

1. The traveling wave applied to transformer
2. Point 97.2% from ground end—Crest 100% of applied voltage
3. Point 83.3% from ground end—Crest 82% of applied voltage
4. Point 75% from ground end—Crest 96% of applied voltage
5. Point 50% from ground end—Crest 62% of applied voltage
6. Point 33% from ground end—Crest 51% of applied voltage
7. Point 25% from ground end—Crest 79% of applied voltage
8. Point 16% from ground end—Crest 79% of applied voltage
9. Point 2.8% from ground end—Crest 13% of applied voltage

In practise, the non-resonating winding is uniform and concentric with the low-voltage winding. The coils are relatively narrow. Standard circular coils are used, connected together successively at the inside and outside turns, so that cross-connections from inside to outside of coils are avoided.

The mechanical design of the transformer follows long established practise, lending itself readily to assembly and handling, and embodies the usual desirable characteristics such as free oil circulation and ability to withstand short circuit stresses.

In the new transformer, voltage stresses between turns and coils under lightning conditions are reduced in the order of from 10 to 1 to 100 to 1. The over-voltage to ground caused by oscillations being eliminated, results in decreasing the stress to ground sometimes as much as 6 to 1. The elimination of local excess voltage between turns and coils reduces the probability of arc-over of tap terminal boards, ratio adjusters, etc.

The proportion of voltage stress in all parts of the winding under all conditions of voltage and frequency remains the same as that during the factory insulation test, which therefore becomes a real measure of the ability of the transformer to resist lightning. This never could be tested correctly before.

In such a transformer, since all voltage stresses are under complete control and are made uniform throughout the winding for all frequencies, the reliability will naturally be much greater than in ordinary transformers.

FOUNDRY COSTS REDUCED BY LIFTING MAGNETS

Lifting magnets may be advantageously used in gray iron foundries for many material-handling jobs. Some of the direct possibilities were pointed out by Albert Walton, consulting engineer, of Philadelphia, at the recent convention of the American Foundrymen's Association. As mentioned by Mr. Walton, magnets may be used for unloading pig iron and scrap from railroad cars, for stocking this material in the yard and for handling it to cupola charging boxes and buckets. In direct cupola charging, if the operation is continuous for a number of hours, it is advisable to use two magnets alternately, since one will heat up considerably in continuous use. The change, however, does not have to be made oftener than every one and one-half to two hours. Magnets may be used for the handling of iron slabs on the molding floor and also for lifting iron or steel copes, picking up and transferring castings to the cleaning room or to suitable trucks and for going over molding floors after the castings are removed and picking up gates, risers, nails and other pieces of iron and steel. By the use of magnets on the work described a reduction in labor cost can be made down to one-tenth of what it would be without mechanical appliances. A single magnet installation will replace ten or twelve men on this class of work and it will do the work more effectively and quicker.—*Electrical World.*

Abridgment of

Meeting Long Distance Telephone Problems

BY H. R. FRITZ[1]
Associate, A. I. E. E.

and

H. P. LAWTHER, Jr.[2]
Associate, A. I. E. E.

Synopsis.—There have been presented before the Institute numerous papers describing various technical and apparatus developments of value in providing long distance telephone service. Several papers have also appeared covering specific transmission or operating problems, or dealing with the advance planning of the telephone plant. Feeling that it might be of interest, particularly to the young engineering graduates, the writers have prepared this over-all sketch of the general problem of actually providing, year by year, the extensions and additions to a comprehensive network of communication channels necessary to keep pace with a growing public demand for long distance service. Since the writers are most familiar with the area served by the Southwestern Bell Telephone Company, the discussion will be restricted to that territory.

* * * * *

THE Southwestern Bell Telephone Company operates in the states of Missouri, Arkansas, Kansas, Oklahoma, Texas, and a small section of Illinois which is socially and economically associated with greater St. Louis. This is primarily an agricultural region but there are several large manufacturing centers and extensive areas devoted to oil and mineral production. The great difference in climatic and soil conditions which exist over such a wide territory naturally brings about a diversity of agricultural interests. Local seasonal peak demands for long distance service occur at the times when crops must be marketed and moved.

Because of its fortuitous occurrence and the sudden and imperative demand for long distance service attending its discovery, oil creates the most difficult problems. Through some preverse trick of fate, the deposits have been found uniformly in areas otherwise of no great economic importance and having either no, or very little, telephone development.

Contributing more than any other item to the problem of keeping abreast of the demand for long distance service is the fact that the Southwest is still immature in the social and economic sense, and is growing lustily, and at a rate which rarely fails to exceed the most optimistic forecasts.

Beside these purely local peculiarities which contribute to the problem, there is the generally increasing demand for long distance service on the part of the public. Based fundamentally on the increase of wealth and prosperity, traffic growth has been accelerated by better service and reduced rates. New and improved apparatus and methods become available from time to time—and not the least of the tasks of the field engineer is the more or less continuous modernization of an existing plant.

With this picture of the factors affecting the demand for service, it will be interesting to note the extent and complexity of the long distance network required. The map, Fig. 1, shows the principal towns and cities of the Southwestern area, and the single lines connecting them represent circuit routes. There may, of course, be a large number of communication channels on each route. Not all of the cities and towns, and not all of the circuit routes shown are Bell owned and operated. Long distance service must be universal and considered independently of who owns and operates the plant.

In addition to the network shown on Fig. 1 there is the long distance telephone plant of the Long Lines Department of the American Telephone and Telegraph Company. This department is organized to supply the extreme long distance facilities necessary between the several Associate Company areas in order that universal service may be realized. This paper does not include consideration of the Long Lines Department's plant or its problem.

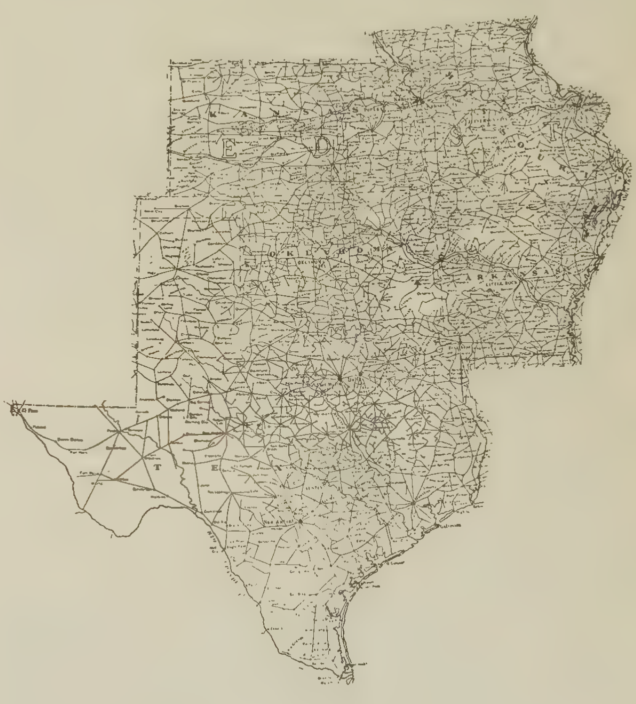

Fig. 1—Long Distance Lines

1. Southwestern Bell Telephone Co., St. Louis, Missouri.
2. Southwestern Bell Telephone Co., Dallas, Texas.

Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request

The fundamental requirements of any link of a system of long distance facilities is that it must talk satisfactorily. It must be capable of transmitting speech easily and without undue effort on the part of the users. To accomplish this, there must be:

1. A sufficient volume so that speech may be received with adequate loudness.
2. Freedom from distortion so that speech will be satisfactorily intelligible.
3. Freedom from extraneous interference.

Each circuit, together with all of its associated equipment, must be designed to comply with these basic requirements. Not only must it furnish adequate transmission as an individual unit, but it must also perform satisfactorily as a link of the whole system.

In addition to regular long distance telephone communication, it is necessary that certain special services be furnished. The radio public demands the chain broadcasting of programs and the frequent picking up of programs at points remote from the radio transmitting stations. This requires the setting up of very reliable and extremely high quality telephone channels. Extraordinary freedom from distortion and noise is necessary, since even with the perfection of modern amplifying and loudspeaking devices the quality of a radio program must exceed that of a simple transmittal of intelligible speech in order that it may prove enjoyable. The simultaneous operation of telegraph over wire facilities primarily placed for telephone service has long been practised. Telegraph facilities, then, are a by-product of the telephone business, and economy dictates that these be made use of as fully as practicable. Picture transmission is still before the public for trial. Should a widespread demand develop, it will be necessary to set up a network of communication channels surpassing all previous standards.

There are three types of facilities available for providing long distance circuits. These are open-wire, carrier-current systems (superposed on open wire), and cables. The first two are closely interrelated and are of service in the early and intermediate stages of development, while the last is the final goal of progress at the present stage of the art.

Open-wire was the first and is still the main reliance for providing circuits in this country. In a large area of low population density, such as that of the Southwest, open-wire must constitute the bulk of the plant for a number of years to come. Three sizes of copper wire now find general application. These are designated 104, 128, and 165, the figures indicating the respective diameters in thousandths of an inch. Improved transmission through the use of copper wire larger than 165 is unduly expensive, while sizes smaller than 104 do not possess the requisite mechanical strength for resisting the stresses of storms. Copper open-wire circuits possess electrical characteristics so ideal as to endear them to the hearts of transmission engineers. With the aid of suitably spaced telephone repeaters they may be extended to practically any distance. Iron wire has lost its place in a plant designed for universal service. Having, when new, a transmission efficiency only one-fourth that of the same size of copper, due to corrosion, iron wire becomes progressively worse from the day of its installation. This instability renders it wholly unsuited to the application of telephone repeater improvement and thus so seriously restricts its flexibility that it has been determined to eliminate iron wire completely from the long distance plant. The application of the principle of loading to open-wire facilities has been rendered totally obsolete on account of the better performance and greater flexibility of non-loaded open-wire with repeaters.

It is generally impossible to continue in open-wire up to the central office in a city. In such instances, it is the practise to terminate the open-wire out beyond the city congestion and to bring the circuits into the office over specially designed entrance cables. These entrance cables must often be of considerable length and add materially to the transmission losses. Through the application of the proper systems of loading, the cable circuits may be made to match the impedances of the open wire circuits, and thus preserve the full possibilities of telephone repeater operation.

For several years now carrier-current systems have been available by means of which additional telephone channels may be derived from existing and suitable open-wire facilities. For distances beyond certain minimum figures, these carrier systems yield telephone channels more economically than possible through the placing of additional open-wire. The outstanding usefulness of carrier systems, however, lies in the increased capacity they confer upon an existing open-wire structure. It is thus possible to defer heavy expenditures for major relief.

There are two types of carrier telephone systems in general use. One provides three additional telephone circuits besides the one furnished by the pair of wires over which it must operate. Under favorable conditions it is economical as compared with stringing of wire for distances of as short as 150 miles, and by the use of carrier repeaters spaced at regular intervals it may be extended to any distance. The other provides one additional talking circuit and finds its application with distances between 50 and 200 miles.

At the higher frequencies of the carrier systems the attenuation offered by the open-wire circuits is greatly increased over that experienced at voice frequencies. When it is remembered that cross-talk effects increase almost directly with frequency and are a function of the energy level differences between the disturbing and the disturbed circuits it will be realized that the application of carrier systems to an open-wire lead may present serious difficulties. Transposition arrangements quite satisfactory for voice frequencies are totally inadequate for the carrier range. Special systems of transpositions must therefore be employed which, in addition to

making use of extremely elaborate patterns, must be spaced with great precision.

The necessary entrance cables which complicate voice-frequency transmission problems constitute a proportionately more serious problem at carrier frequencies. To reduce attenuation and to limit reflection effects, the cable conductors must be suitably loaded for carrier operation. For the frequency range employed by the three channel system, loading coils must be placed at 930-ft. spacing. In the case of underground construction, it is rarely possible to realize this ideal spacing on account of manhole locations. It then becomes necessary to place the loading coils at something less than the theoretical spacing, and to build out the short sections to the required capacity by means of special stub cable connected in shunt with the loaded conductors. In order to avoid carrier cross-talk in entrance cable it is necessary to maintain a degree of segregation among the conductors assigned to carrier operation.

Despite elaborate preparations in the form of special transposition of the open wire and loading and segregation of entrance cable conductors, it is still not possible to operate carrier systems indiscriminately on any open-wire lead. Serious energy level differences and opposite directions of transmission with the frequency groups must be avoided. All the systems on a lead cannot always be coterminous, for a lead may be hundreds of miles in length, while carrier systems over it will serve various intermediate and overlapping lengths. At any intermediate point it may be desirable to introduce a system terminal with its high output level to operate in parallel with other systems whose energy has been greatly attenuated in transmission from distant terminals. Such differences in level have to be minimized either by separation on the pole head or by the introduction of repeaters to raise the lower energy levels. Junctions with other open-wire lines and the generally complex nature of the open-wire network give rise to situations such that it is practically impossible to realize completely the theoretical carrier possibilities.

Further exploitation of the remaining carrier potentialities on open-wire leads is blocked by the use of phantom circuits which definitely limit the transposition refinements needed to restrict the cross-talk. For important open-wire leads consideration is therefore being given to abandoning phantom circuits on all wires of the first four arms, except the pole pairs. A further simplification of the cross-talk problem can be made by reducing the spacing between the wires constituting a pair from 12 to 8 in. and correspondingly increasing the spacing between pairs from 12 to 20 in.

The nature of the long distance telephone development and the growing requirements of the Southwest have furnished a particularly favorable field for the application of carrier telephone. The distance between many of the more important cities is from 200 to 300 mi., and the three-channel system has been made large use of in spanning these. The single-channel system has found equally widespread application. The use of carrier telephone has grown until the present day finds some 35,000 mi. of telephone channel obtained by this means in the Southwest. The map of Fig. 2 shows the extent of this development, which represents about one-sixth of that of the entire United States.

From the discussion so far it is clear that with any open-wire lead the condition will be reached ultimately when the maximum wire load is in place and the fullest possible use of carrier has been made. It then becomes necessary either to build additional open-wire lines or else have recourse to some other means. Where the circuit growth is sufficiently rapid, economic studies rule in favor of cables in place of building one or more supplementary open-wire lines. In addition to proving in from a strict economy standpoint, cables offer many advantages as a medium for long distance circuits. Increased freedom from interruptions due to physical failure of the plant, lower susceptibility to external interference, and more stable operating conditions are some of the benefits accruing. In the territory of the Southwest, the condition is rapidly approaching when cables will be needed between nearly all of the important centers. To meet this situation a cable program has been adopted for the period 1929-1933, which will connect most of these points. This is shown on the map of Fig. 3. Of the cables in the program the sections between Oklahoma City and Tulsa, Oklahoma City and Holdenville, and Dallas and Cisco are under way and will be completed during 1929. As it now stands, the

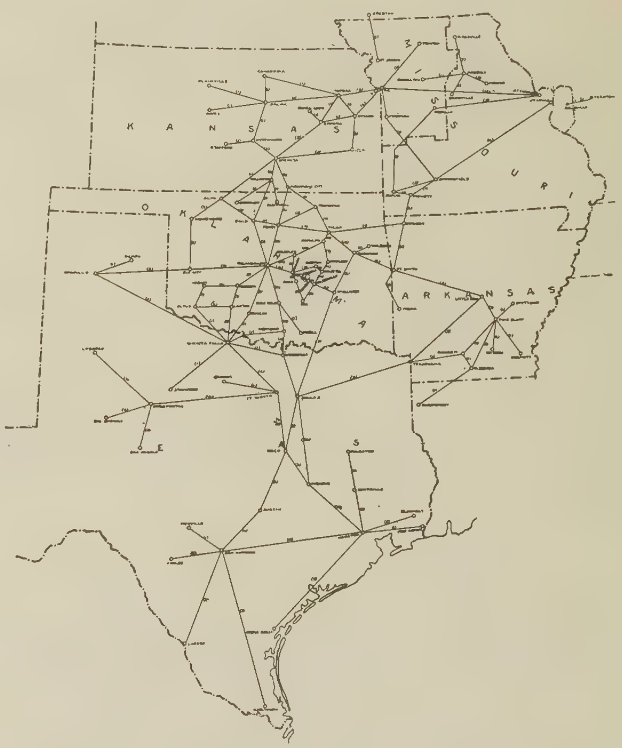

Fig. 2—Carrier Circuits in Southwest

program provides for a total of approximately 2600 miles of cable for the five years.

The Tulsa-Oklahoma City and the Fort Worth-Cisco sections of the cables mentioned above will represent a unique departure from the previously standard practises of this country. The usual lead-covered cable is to be manufactured and then given a protective coating including several layers of jute and tar and two servings of steel tape armor. A trench is to be dug and the cable simply placed therein and

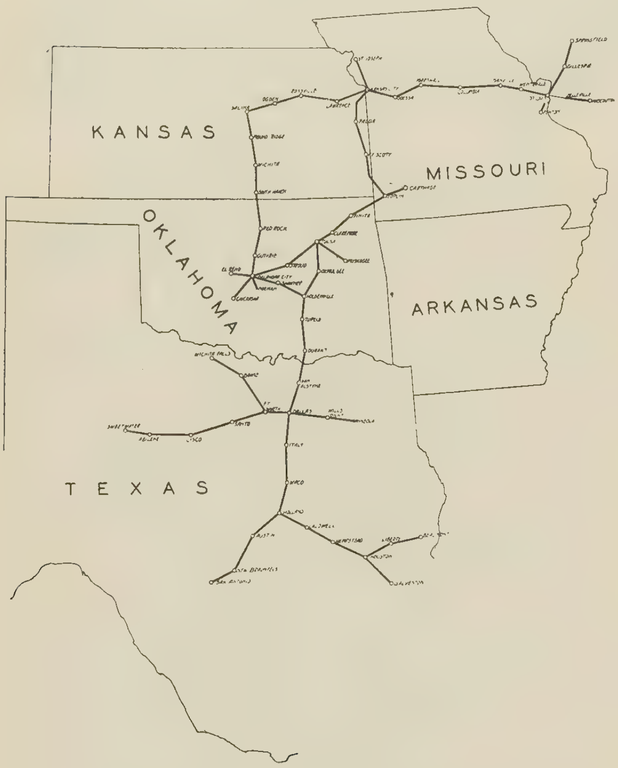

Fig. 3—Toll Cable Program for Period of 1929-33

covered up. When it is realized that a standard 750-ft. length of this armored cable, together with its reel will weigh about five tons and that the route is to be strictly cross-country, it will be appreciated that some interesting construction difficulties must be met and solved. It is planned to present the story of these installations to the Institute at a later date.

Whether the channels for long distance circuits are derived by means of open-wire carrier systems, or cables, elaborate installations of equipment are required at the circuit terminals and at the intermediate repeater stations. The placing of this equipment and the providing of the necessary building space for housing it constitute major problems. Building additions must be made or even complete new buildings erected, new equipment must be installed and placed in service, and existing working equipment must be relocated to best advantage—all without interrupting the service. Also, irrespective of the means used to derive the communication channels, arrangements must be made at the terminal offices whereby any two circuits may be connected together and a built-up connection thereby established between two terminals not having direct-circuit connection. The problem comes in arranging for such interconnections with the result that built-up connections shall satisfy the same fundamental transmission requirements as are demanded of the individual links. To meet the volume requirement it is essential that a definite gain be inserted whenever two circuits are connected together. The practise of the past has been to provide with repeaters certain of the cord circuits appearing at the switchboard positions which handled switched traffic. The fundamental weakness of this method lay in the fact that the insertion of the proper gain was left in the hands of a very human operator, and there was always the possibility of its being omitted. The latest practise eliminates this element of human fallibility. The switchboard positions are equipped with but one type of cord circuits. When a connection is established between two long distance circuits the proper gain is automatically provided; when a connection is established between a long distance circuit and a local telephone no gain is inserted since none is necessary. The distortion and interference requirements are met for built-up connections simply by causing the individual links to meet sufficiently high standards in these respects so that a chain of four or five in tandem will still yield a satisfactory grade of over-all transmission.

An interesting review of the growth of the various

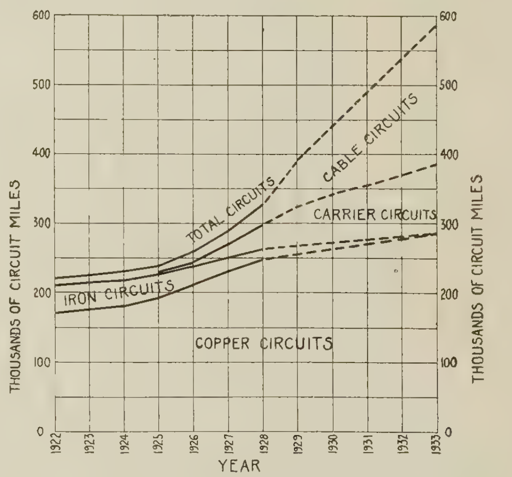

Fig. 4—Growth of Long Distance Circuits

types of facilities used to derive long distance telephone circuits in the Southwest is shown on the diagram of Fig. 4. The rise and fall of iron wire, the abrupt rise to prominence of carrier systems and cables, and the rapidly mounting total are significant of the present trends.

Abridgment of

Developments in Network Systems and Equipment

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Synopsis.—*This paper in its complete form presents in brief review the development of the automatic network system in the seven years since its introduction. It covers the interesting features of design found in the different systems, the changes that have been made in the design of the apparatus as a result of experience, some of the problems that have been faced in the application of the system, and finally the lines along which thought is now being directed in the future development of the system.*

THERE has been a great deal written in recent years in regard to the a-c. low-voltage network type of distribution system. The various requirements which caused such a system to be evolved, the fundamental principles of the design and operation of such a system, and the equipment used in it have been described in various technical papers. It is felt, however, that it would be interesting at this time to review the growth of the network system and to observe what developments have occurred in its design and to point out what changes have been made in the apparatus used as a result of the experience gained and in order to meet the requirements of various types of systems.

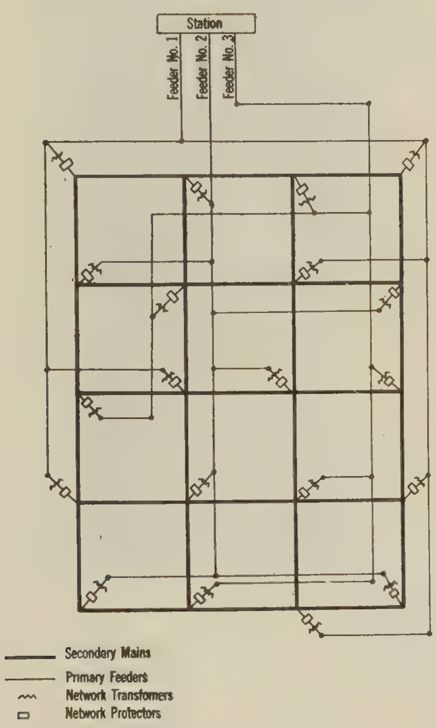

Fig. 1—Diagram of Small Automatic Secondary Network System Supplied by Three Interlaced Radial Feeders

A single-line diagram of an automatic secondary network system is shown in Fig. 1. The United Electric Light & Power Co. installed the first system of this type in the up-town district of New York City in 1922.[3]

In this country, 22 companies now each have a system of this type in operation, six are installing it, five have decided upon it, and it is being given serious consideration in at least 20 other localities. The network has been introduced in four foreign cities,—one in Cuba, one in Mexico, and two in South America,—and is being seriously considered by one other South American and one European city. In all of these systems the fundamental principles of the original design have been retained, but the details of the layout have naturally been adapted to meet local conditions.

Network Protectors

The piece of apparatus that has made the automatic network system possible is the network protector. Although there was no extensive experience on which to base the original design, it is worthy of note that with only minor modifications it has stood the test of service for a period of five years. During this period the protectors on one system were called upon to open or close a total of more than 200,000 times and the number of times that they failed to function properly amounted to less than four-tenths of one per cent. The reports on the operation of the switches on other large network systems show even better results.

About a year and a half ago it was decided to make a complete redesign. A new network protector was brought out which retained all of the operating principles of the original unit but had incorporated in it the features that five years' experience had shown to be desirable. Two views of this type of protector mounted in a subway housing are shown in Figs. 2 and 3.

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2. General Engineer, Westinghouse Elec. & Mfg. Co., St. Louis, Mo.

Presented at the Regional Meeting of the South West District No. 7 of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

3. *Underground A-C. Network Distribution for Central Station Systems*, A. H. Kehoe, A. I. E. E. Trans., Vol. XLIII, 1924, p. 844.

Because of the good service it had given in the first type of protector, the circuit breaker type of construction was retained. A rather novel arrangement was adopted, however, by means of which the moving contact is made an integral part of the main copper bus and is simply laminated to give the needed flexibility.

The advantages of a motor-operated closing mechanism over a solenoid type in the reduction of the jarring at the time of closing, the reduction of the current required to perform the operation and the consequent reduction in the size of the device required to break this current has been appreciated for some time. This type of device was not used on the original unit, however, because of the lack of a suitable low-speed motor mechanism including a trip-free feature to permit the protector to open at any time without retardation due to the action of revolving flyballs. Such a mechanism was developed and the motor was adopted as the standard closing device in the new protector.

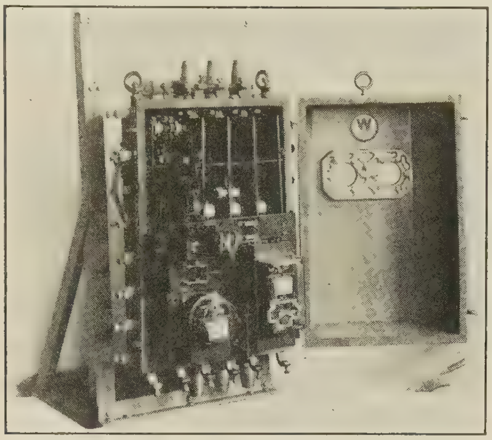

Fig. 2—Network Protector with Control Panel Closed

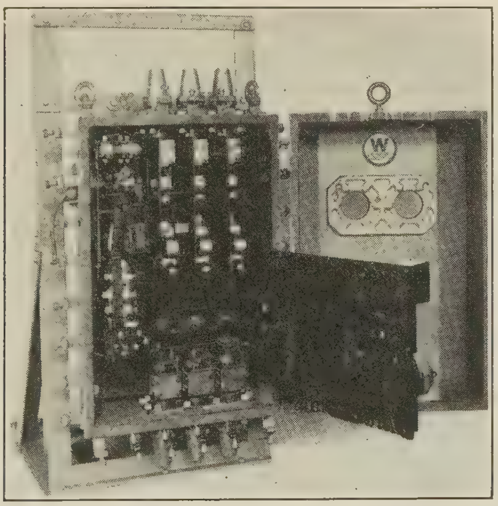

Fig. 3—Network Protector with Control Panel Swung Open

The action of the motor is transmitted to the breaker through a system of levers which has been so designed that the breaker is locked closed by the action of a toggle joint being drawn over the center. As a result of this, no latching triggers are in motion while the breaker is closing and the danger of the breaker failing to remain closed in minimized.

The shunt trip device was adopted as the standard in the new protector but only after the design of the entire mechanism was made such that as little as 15 volts impressed across the shunt trip coil will supply the energy required to cause positive operation. It is not likely that a condition will ever present itself where less than 15 volts will be available for tripping.

One of the biggest problems confronting those who designed the first network protector was the development of a type of relay in which could be centered the entire control of the protector. The satisfactory manner in which this design was worked out is shown by operating records which indicate that only about 25 per cent of the very small amount of trouble experienced with the original protectors can be charged against the relays. It is true, however, that the design was rather complicated and in redesigning the foremost purpose was to simplify and at the same time retain and improve the operating characteristics.

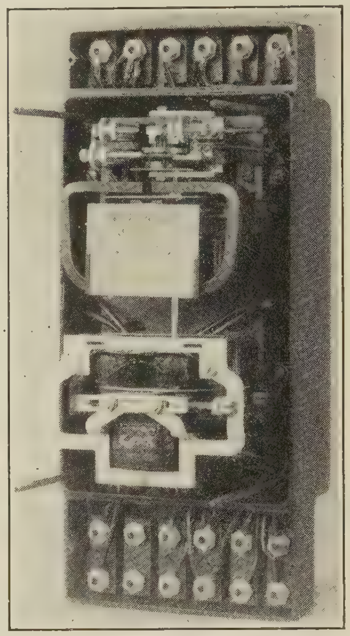

Fig. 4—Three-Phase Network Relay (Glass Cover and Terminal Chamber Covers Removed)

A three-phase relay was developed to take the place of the three single-phase relays that were formerly used. The three-phase relay has decidedly better closing characteristics than the single-phase type and also gives somewhat better performance under certain secondary fault conditions.

The detailed design of the three-phase master relay

represents a decided simplification. It has been possible to design a relay having wattmeter tripping and approximately wattmeter closing characteristics and still eliminate the holding coil, adjustable slide wire resistor, fixed resistor and auxiliary contactor which were required in the first network protector relays. A view of the three-phase relay is shown in Fig. 4.

There are system conditions under which pumping,—that is, periodic opening and closing of the network protector,—might result with a three-phase relay as well as with the three single-phase relays. To prevent

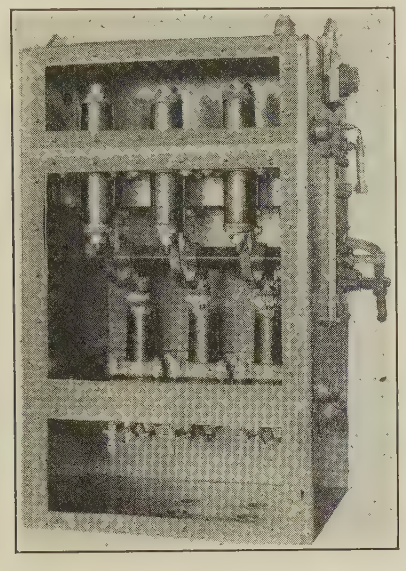

Fig. 6—Separately Mounted Grounding and Disconnecting Switch

this a single-phase relay known as a phasing relay is supplied along with the three-phase master relay. When acting along with the master relay the phasing relay prevents the protector from closing under any conditions where the current that would flow after closing might cause the protector to reopen again and thereby absolutely prevents pumping action.

The entire design of the new protector has been worked out on the basis of maximum accessibility for maintenance and repairs. Everything is mounted on the front of the panel and the entire protector has been built up on the unit principle.

Network Transformers

In the first network systems installed the transformers used were of the same standard type as those on the radial systems. Since that time, however, it has been found desirable to incorporate other features so that there has developed what is commonly called a network transformer particularly designed for service on this type of system.

Although only one-third of the companies operating or installing network systems have thus far decided to use any three-phase network transformers, still this number is continually increasing and there is a definite trend towards the use of this type, particularly in those systems where new transformer manholes are being built and it is a relatively easy matter to provide the larger opening required.

It is considered desirable to locate at each transformer bank some device for grounding the feeder which supplies it. A man working on the feeder cable or any of the high-voltage apparatus connected to it can then make sure that the feeder is grounded in the immediate neighborhood of the section on which he is working. The first device brought out for this purpose consisted of a small switch mounted inside the transformer.

As operating experience grew it was found that it would also be desirable to have some means of disconnecting each transformer from its feeder as an aid to testing and in order to keep any transformer out of service because of failure or for any other reason without keeping an entire feeder deenergized. This resulted in the development of the three-pole three position switch mounted in the high-voltage terminal chamber.

In the case of single-phase transformers the advantages of mounting the switches in the terminal chambers

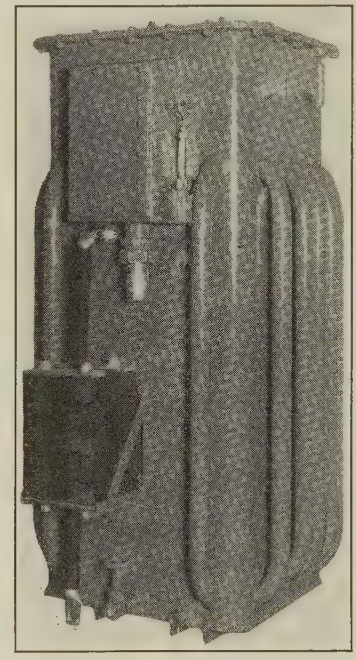

Fig. 7—Single-Phase Network Transformer Using External Reactors

still exist but a somewhat more difficult problem presents itself since it is necessary to mount a two-pole switch on each single-phase unit. The San Antonio Public Service Co. decided on the use of single-phase transformers in the network system that is now being installed and rather than use a separate switch on each transformer adopted the plan of using a three-pole, three-position switch mounted apart from the transformer. A view of this switch with the front plates removed is shown in Fig. 6.

Tap changers which may be operated by handles brought through the cover of the tank are supplied in network transformers. It has been found desirable in service to have some control of the ratio of the step-down transformers and the tap changer has been adopted as the simplest means of accomplishing this with the transformer disconnected from the circuit.

One of the important questions that presents itself to any company designing a network system is the value of reactance that should be used in the network transformers. The higher the impedance of the transformers as compared to the impedance of the secondary tie cables, the better will be the load division. Since a network is designed so that any feeder and all of the transformers connected to it may be taken out of service and left out indefinitely, it is rather important that the remaining transformers share the extra load as much as possible. Besides improving the load division the high reactance also has the advantage of reducing circulating currents between feeders which in turn leads to more stable operation of the network protectors, particularly under light-load conditions. These two considerations have caused the large majority of companies operating network systems to adopt the policy of using ten per cent impedance at the transformer banks.

If a company decides to use transformers having ten per cent impedance, the next problem is to determine the most satisfactory manner in which to obtain the increased value. There are three methods that have been used up to the present time. The first method is to have the increased reactance built into the inherent design of the transformer by coil spacing and grouping. In the second method the increased value is obtained by the use of shunt iron paths in the transformer. As a third means, transformers having standard reactance may be used and this can be raised to any desired value by the addition of small reactors in the cables coming out from the transformer.

Taking all factors into consideration it would appear that the use of transformers having not more than five per cent inherent reactance, with any additional amount desired obtained by means of external reactors, is the most satisfactory arrangement for the system having usual load densities because of its flexibility.

Fig. 7 shows the low-voltage side of a single-phase network transformer and illustrates a rather convenient method of mounting the external reactors.

Present Trend of System Development

Up to the present time only one company, the Knoxville Power & Light Co., is operating an overhead automatic network system of any appreciable size. The question of using networks in such areas has been given serious consideration by other companies and it is believed that decided advances will be made in the development of such systems within the next few years.

The first two of a group of large government buildings are now under construction at Washington. The automatic network system has been chosen as the most satisfactory from an engineering standpoint as well as the most economical type of system that could be used to supply these buildings. Each building will have a secondary cable grid tying together the transformer vaults located in that building and the secondary networks of all of the buildings will be connected solidly together by low-voltage tie cables.

This development is only the forerunner of a widespread application of network systems inside large buildings if the amount of thought being given the problem at the present can be taken as a criterion. Directly connected with this subject is the one of vertical distribution in tall buildings which is being actively considered by two companies at the present time. Preliminary plans call for the location of transformers on several different floors, the group of transformers on each floor being connected into a network which may be permitted to remain independent or may be tied in on the secondary side with the networks on other floors. Along with this development, consideration is being given to every detail of the vault layout and the design of the apparatus to minimize the possibility of a transformer explosion and to localize trouble of any kind.

As a system of distribution for large manufacturing plants the a-c. network is being given serious consideration. In this field such a system should find its greatest application in those factories where the process of manufacture is such that an outage of even a short duration has serious results. A special type of automatic network system is being considered for one manufacturing plant of this type at the present time.

The network system lends itself exceptionally well to the scheme of synchronizing generators at the load. One company that is operating a large network system is now making a thorough investigation of the feasibility of such operation.

The network stands today as a type of system that has stood the test of service and has given the results expected of it. In general, the continuity of service in practically every installation has been as dependable as the source of supply and most thought is now being given to possible means of increasing the dependability of the source.

DETROIT AND CANADA TUNNEL

The first tube of the Detroit and Canada Tunnel has been sunk to a bed of mud 80 feet below the surface of the Detroit River. This tube is one of ten which will comprise the under-water portion of the $25,000,000 tunnel project. The ten tubes vary in length from 220 to 250 feet, with an over-all diameter of 35 feet. Their aggregate length is approximately half a mile ,constituting the underwater part of the tunnel.

The tubes when launched weigh in the neighborhood of 500 tons each. At the time of sinking, each tube after being concreted weighs from 7000 to 8000 tons.

Abridgment of

Flying Field and Airway Lighting

BY H. R. OGDEN*

Non-member

***Synopsis.**—This paper discusses methods of lighting airports and airways and describes various types of lamps and equipment used for this purpose. In the information on airport illumination are included beacons, obstruction lights, boundary lights, illuminated wind direction indicators, field and building floodlights, signal lights, and ceiling illumination. The portion on airway lighting covers principal and intermediate beacons and emergency field lighting. An extensive bibliography is included in the complete paper.*

* * * * *

DURING the last few years many fundamental problems of illumination for night flying have been solved by both civil and military organizations. Although the future may see considerable divergence between military and civil lighting practise, at the present time both are similar and, in fact, commercial aviation has largely followed the trend of military design.

The components of a complete lighting system for an airway and its terminals have gradually increased in number as the need for their existence has become evident through experience. Particularly is this true of the equipment at the terminal airports. The following components should be considered in planning a system for lighting a terminal flying field, in this order of importance: (1) beacon, (2) obstruction lights, (3) boundary lights, (4) illuminated wind direction indicator, (5) floodlights, (6) building flood lights, (7) signal lights, (8) ceiling projector. The components of a lighting system for an airway will be given later.

If the problems confronting the night pilot desiring to land are based upon a succession of observations and decisions, we may well attack those problems in the order in which they occur to the pilot.

Airport Beacon. No mariner ever experienced greater satisfaction in identifying a lighthouse than a night pilot feels when he is uncertain of his exact location and finally espies the aerial beacon for which he has been searching the horizon. Due to lack of sufficient fuel to remain aloft, the majority of night flights must be terminated before dawn. A landing field must be located before the fuel is exhausted.

There are various types of airport beacon in use at the present time. The most common in the United States is the rotating searchlight type with a 24-in. dioptric lens, 1500-watt incandescent lamp, and parabolic reflector. An electric motor in the base rotates the light. A recent development of the light includes a lamp changer mechanism which automatically brings a new lamp into position and incandescence, at the same time giving a warning of the burned out lamp at the control office.[5, p. 2] The beam has a vertical divergence of from 3 to 4 deg., and a horizontal divergence of from 10 to 40 deg. The greater horizontal divergence increases the length of flash but decreases its intensity. This difficulty of securing great intensity and length is the only criticism that can be made against this beacon. Even with a 40-deg. horizontal divergence, the length of flash is only 1-1/9 sec. at 6 rev. per min. But the more serious fault of this periodicity is the eclipse of 8-8/9 sec. Equal periods of flash and eclipse would be more suitable but a beacon furnishing such a light appears to be more costly. A 360-deg. light house lens with revolving reflector would provide such a light.

To secure proper distribution of the lower edge of such a beacon beam along the horizon, some method of adjustment ought to be incorporated in the light, either by an adjustable pivot or an adjustable base. The latter appears to be more practical. The French are using tripod type of mount for this purpose on some of their lights.

If a water tower is located in the vicinity of the airport, it may be fitted up as a satisfactory short range beacon by painting the wall of the tank white and floodlighting it by means of sign-board flashing lights surrounding the periphery. Since such a tower would otherwise have been wired for obstruction lights to safeguard pilots from colliding with it, the cost involved comprises only the lamps, fixtures, sign-board flasher, and white paint. A sufficient number of light sources would provide against interruption of the beacon caused by a burned out lamp.

If for any airport lighting system the range of the water tower beacon is not considered sufficient, the tower may still be used to good advantage to mount on its peak any other type of flashing beacon. There are two advantages gained in mounting the flashing beacon on a tower high above the landing field. First, it allows the lower edge of the light beam to be adjusedt below the horizontal, in line with the new horizon. This gives greater range of the beacon to a low flying airplane forced to fly near the ground by low clouds. Setting a beacon 100 ft. above the ground increases its

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1. All references are in Bibliography in complete paper.

Presented at the Regional Meeting of the South West District of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

range at ground level 13 mi. Second, a flashing beacon near the ground is disconcerting to a pilot about to land. When the intense rays of the beacon strike his eyes, the pupils converge and handicap his vision. A high mount for an airport beacon is therefore a distinct advantage.

At the Croydon airport, London, a unique beacon has been tested and been found to possess unusually good visibility in thick atmosphere. It consists of a moving chain passing through a solution of strontium and then through an oxy-acetylene flame. The resultant light is very intense, but its superiority to an electric beacon does not appear to be sufficient to warrant its general adoption. In direct comparison with the strontium beacon, the Croyden airport is equipped with a truncated cone neon beacon, which is reported to pierce a small amount of fog better than any other beacon at the field.[3, p. 4]

The last beacon, and probably the favorite of night pilots, is the lighthouse type of beacon with 360-deg. Fresnal lens units. For the same power input, these beacons do not have the range of the searchlight type due to the fact that the light is diffused over 360 deg. as compared to from 10 to 40 deg. for the searchlight type. But on the other hand, the lighthouse beacon can be designed to give any type of flash desired. The largest beacons of this type are located in France, one near Paris and one near Dijon. Each has 1,000,000,000 cp., sufficient to give a range of visibility of 100 mi. in clear weather.

To sum up the present practise in the use of airport beacons, the projected beam type is most common in the United States, the Fresnal lens lighthouse beacon is favored in France,[4, p. 1] while the flashing neon beacon is extensively used in Germany.[4, p. 3] England, also, is partial to the neon beacon due to the claim for its fog piercing quality. Since the Fresnal lenses are expensive to manufacture while the neon tubes are expensive to operate, it is evident that European practise in night lighting does not consider the cost so important as superiority of equipment.

Obstruction Lights. After a pilot locates his landing field through the aid of the airport beacon, he approaches the field and observes obstructions which he must avoid while examining the landing area, the wind direction indicator, and ships about to land or take off. Crashes which occur through colliding with other airplanes near the ground or with obstacles while still in flight are usually fatal to the occupants. The obstruction lights are therefore very important in any plan for lighting an airport. A careful analysis must be made of the probability of an airplane colliding with any obstacle within a half mile of the field, and other obstacles farther away which are on the direct line of an airway. It is reasonable to assume that no pilot will fly lower than 100-ft. altitude until actually making his approach for landing. Ordinarily, no obstacles less than 50 ft. high, which do not immediately surround the field, need be lighted. However, each field presents special problems, and no set rule can be made. It should be borne in mind that an airplane glides at an angle never steeper than 1 to 5. This will indicate roughly what structures or natural objects in the vicinity of an airdrome should be considered obstructions. A compromise between ultra safety and cost must always be made. Poor pilots will sometimes hit obstacles in spite of everything that can be done to safeguard them.

The universal practise in Europe and America follows the recommendations laid down at the International Air Convention for marking obstacles with red lights. The Material Division of the Air Corps recommends the use of 50-watt lamps in ruby globes of high light transmission qualities.[6, p. 4] The lights burn steadily and may be connected with the field lighting circuit. The lamp fixtures should be placed so that the obstacle light can be seen from the horizontal to the zenith in all directions, and from the ground anywhere on the airdrome.

Boundary Lights. When the pilot of an airplane has observed all obstructions about a field upon which he intends to land, his next observation is usually to determine the extent and nature of the field. Boundary lights can answer both of these questions. The Department of Commerce has made a careful study of the boundary light problem and has published the results in Aeronautics Bulletin No. 2.[1, p. 12] That bulletin should be consulted in drawing up a plan for an airport lighting system.

The general practise for placing boundary lights is to outline the field completely except along the hangars, outline just the corners of the field, or outline the runways. The last method is most expensive, and, in the case of raised lights, invites collision from a rolling airplane. However, with the lights installed flush with the ground or raised only a few inches, permitting an airplane wheel to roll over without damage, this system has a distinct advantage. It enables the field manager to indicate clearly the best approach and best place to land under various wind conditions by merely lighting the one runway which should be used.

A special plea is made for the design of boundary lights which are fairly indestructible. The present practise of installing a lamp 1 to 3 ft. above the ground on the top of a pipe set in concrete[1, p. 12] has one insurmountable drawback. The installation attracts the attention of curious people, and invites malicious people or undisciplined children to break or pilfer the globes and lamps. No measure short of a constant guard near such boundary lights will protect them from depredation. Landing fields are too large for a manager on one side of the field to be responsible for the protection of the boundary lights on the opposite side. The design of lights flush with the ground will not attract so much

attention, and it is believed that they can be made fairly indestructible, at the same time fulfilling the purpose for which they are installed.

Another advantage can be gained by using boundary lights flush with the ground. Instead of establishing a row of lights on the very edge of the landing area, such a row could be placed 300 ft. from any edge along which a telephone or power line was located. Thus, a normal glide to the edge of the boundary lights would insure the pilot's clearing the poles and wires by a safe margin. In addition, lights placed away from the edge of the field would be less conspicuous and less likely to be molested.

Illuminated Wind Direction Indicator. Normal landings are always made into the wind in order to reduce the ground speed of the airplane as much as possible and retain directional control after the airplane is rolling on the ground. To indicate the direction of the wind to the pilot about to land, several devices are in use. For daytime operation, a wind cone of fabric attached at the larger end to an iron ring free to rotate about a vertical axis, and tapering from about 2-ft. diameter at the ring to 1-ft. at the smaller end, has been in use since the beginning of heavier-than-air flying. The first illuminated wind direction indicators naturally were developments of the wind cone. One authority maintains that illuminated wind cones are not satisfactory,[6, p. 5] but a number of internally illuminated wind cones have been in service at a large Air Corps field for nearly a year and have given uninterrupted satisfactory service.[7] Such indicators are unquestionably the cheapest to install and maintain.

Another type which is popular in England and Germany is a system of lights sunk flush with the ground level, so controlled by either a wind vane switch or manual operation in the administration building that an illuminated T is visible to the pilot.

The best military practise in America calls for an externally illuminated T situated on the ground in front of the operation office of the field. It consists of a skeleton framework built in the shape of a T, carrying a vertical fin at the base of the T to hold the head of the T into the wind, all covered with airplane cloth, and suitably finished.[6, Fig. 6] It is supported horizontally above the ground on a pivot located at the center of gravity. The illumination is provided by two rows of 10-watt lamps located on top of the T. The current is transmitted through a brush arrangment on the supporting bearing. For night visibility the best color for the T is white, whereas for daytime visibility the most satisfactory arrangement developed to date is a chrome yellow T riding a cement or wood background painted black. A good compromise would be a white T on a black background.

The best practise seems to indicate a single wind-direction indicator suitable for both day and night, either an illuminated wind cone or illuminated *T*. The latter is visible a greater distance, and therefore is more satisfactory to the flight leader of a formation of airplanes. The former is more economical and ought to fulfill the needs of most civil airports when properly designed.

Floodlights. No component of airport lighting systems has received so much attention and been the subject of so much experiment in this country as the airport floodlights. The problems connected with floodlighting have been many. At the same time, an airplane properly equipped for night flying is less dependent upon floodlights than upon several of the airport lighting components generally considered less important. Landing lights now available for installation on airplanes, developed by the Materiel Division of the Air Corps, make landing at night reasonably safe when the landing field is properly boundary lighted. However, floodlights must be available in an emergency, and floodlights also improve the ability of a pilot to judge his height above the ground.

Since the manner in which a pilot should pass floodlights in landing is an important factor in determining where the lights should be placed, considerable experimenting has been done along this line. Some pilots recommend that the pilot glide down to a landing over the light and parallel to the beam; others, that he glide diagonally across the beam from the rear; and still others recommend that a landing be made perpendicular to the beam. However, the last recommendation is based upon the use of a single light source of the 180-deg. Fresnal lens lighthouse beacon type, or a battery of projectors arranged along the side of the field. The disadvantage of the first method is that when the airplane enters the beam near the ground, the pilot is suddenly confronted with the shadow of his airplane extending far out in front of him. This disadvantage becomes less annoying as the path of a landing airplane is changed to a perpendicular to the light beam. No one recommends landing into the glare of a light.

For several years the students at the Air Corps Advanced Flying School have been landing straight down, or diagonally across the rear of the beam from a 500,000,000 high-intensity arc, whose beam had a 40-deg. lateral divergence and a 4-deg. vertical divergence. No difficulties have been experienced, and the embryo pilots found the landings quite easy. However, recent experiments at Wright Field, the home of the Air Corps Materiel Division, indicate that even better results can be obtained by greater lateral divergence of the beam and landings made perpendicular to the principal axis of the beam. If the foregoing premise is accepted, then the floodlighting of any field to take care of various wind directions resolves itself into the use of two light sources or two batteries of light sources on adjacent sides of the field. Only the light from one side of the field will be operating at any one time and landings can be made either parallel to that side or diagonally away from it. The arrangement of floodlights is discussed and illustrated thoroughly in

the Department of Commerce Aeronautics Bulletin No. 2.[1, p. 14.]

The practise followed in the design of floodlights has been in the direction of two entirely different types of light units. Experiments in America for a number of years were restricted, for lack of funds, to the searchlight type. Many of these units were manufactured during the World War, and were available for experiment. A 36-in. drum with a parabolic reflector and a high-intensity arc light source was fitted with a dioptric lens which diverged the light beam laterally to a 40-deg. spread. This unit required the constant attention of an operator, the light emitted was not always steady, and when the arc had to be replaced a serious interruption of the light ensued. The first improvement of the unit consisted in substituting a 10-kw. incandescent lamp for the arc. The new light source did not have the same candlepower as the arc, nor was the color of the light so good, but the rays were steady, a prompt lamp change could be made, and the quality of the light was satisfactory. The last major improvement was the incorporation of a lamp changer mechanism which automatically brought a new lamp into position and incandescence, and gave a warning signal in the control room when a lamp burned out. As a single narrow beam, single source floodlight, this unit is very satisfactory.

However, such a unit lights only a limited portion of the landing area. The advent of formation flying at night will require a wider distribution of light. To secure a greater light spread would require a battery of such lights, the combined over-lapping light of which would be much more intense than necessary. To secure a sufficient spread of light at a reasonable cost would require either a new type of single source light with a larger lateral divergence, or a battery of smaller projectors.

European practise invited the attention of American engineers to the 180-deg. Fresnal lighthouse lens floodlight which has been tested comparatively with various types of floodlights[12] and found to be superior for the operation of airplanes in formation. A low mounting of the light, with a sharp cut-off on the upper edge of the beam, produced the most favorable illumination. One objectionable feature of this installation is that irregularities in the surface of the landing field produce shadows.

To overcome this serious objection on irregular fields, a battery of six smaller 24-in. drum projectors with parabolic reflectors, 1500-watt lamps, and 40-deg. dioptric spread lens can be mounted on 10- to 15-ft. standards and spaced 200 to 300 ft. apart along the side of the field. This equipment is much less expensive than the single source lighthouse lens floodlight, is preferable for irregular surfaced fields, and is therefore to be recommended for moderate sized airdromes from which airplanes operate one at a time.[12, p. 6] The cost of lighthouse lens units will probably limit their use to military airdromes and major terminals, while the coming host of smaller municipal airdromes will be equipped with batteries of 24-in. projectors. The present equipment which is being manufactured for flood lighting needs only to be installed properly to give entire satisfaction. Many refinements will be made in the future, but at least the fundamental problems have been solved.

Airway Lighting. The components of an airway lighting system are; (1) principal flashing beacons, (2) intermediate beacons, (3) emergency field lighting. Practise in airway lighting in Europe and America has been widely different, but as time goes on, the respective systems are growing more similar. Europe began lighting its airways with widely separated beacons of tremendous candlepower. Two beacons are 1,000,000,000 cp. each, located at Mount Valerien and Mount Afrique in France. Moderate sized intermediate beacons are located at the terminal airports,[4, p. 20] and still smaller beacons are being installed along the routes. In Germany, the majority opinion favors comparatively low power lights at frequent intervals from 1 to 2 mi. apart.[4, p. 4] On the Berlin-Konigsberg and Berlin-Amsterdam routes are used double series of neon lights which burn continuously night and day. Operation cost of each light is claimed to be about one dollar per month.

American practise began with the installation of beacons spaced close together, though not so close as in the present German practise. And now larger beacons are gradually being used at major terminals to supplement the small beacons.

England has favored the automatic unattended gas lights,[4, p. 11] for aerial route beacons, and the Bureau of Aeronautics in our Department of Commerce has installed these beacons on some of the air mail routes where electric power is not available and the lights must operate unattended for long periods of time.

Emergency landing fields are being established at approximately 25-mi. intervals along the air mail routes. Most of the flashing beacons are located at these emergency fields. The lighting equipment in addition to the beacon consists of boundary and obstruction lights, and an illuminated landing T.

Future Developments. The impetus which Congress gave to aviation through the establishment of a Bureau of Aeronautics in the Department of Commerce has been very great. The increase in night flying, encouraged by the night air mail and the installation of airway lighting, has been remarkable. Although the fundamental problems of aviation lighting have been solved, much important work lies ahead. As already mentioned there will probably be a continual divergence in practise between the requirements for civil aviation and military aviation. Two factors dictate this divergence; utility and cost. Night flying in the Army and Navy will develop into the operation of groups of

airplanes as opposed to airplanes operating singly, so that flood lighting systems will probably be designed along two different lines. Also, military aviation will require mobile lighting units as well as permanent peace time installations, and therefore the development of dual equipment will require larger expenditures for military lighting than for civil. However, as will be noted in this paper, those who are charged with the design and installation of lighting equipment for private, municipal, and federal airports and airways will continue to draw upon the knowledge acquired and experience gained by the pioneering work of the military services, and particularly in this country by the Materiel Division of the Air Corps. It is vitally necessary for the military services to pioneer in the development of material which will improve the system of national defense. It is also reasonable that where such development is useful to civil progress, the knowledge gained through the expenditure of public moneys should be extended freely to the public when not inimical to the security of the nation. Such are the conditions surrounding the development of almost all aviation lighting equipment by the U. S. Air Corps. When the business of furnishing lighting equipment to civil enterprises grows to larger proportions we can look for great experimental work to be done outside of the Army and Navy. That such a time will come is certain. The Army has for several years been drawing upon the ideas of commercial airplane designers for improvements in airplanes, and the day is not far distant when very superior aviation lighting equipment will be designed for civil use.

Abridgment of

Bessel Functions for A-C. Problems

BY HERBERT BRISTOL DWIGHT*

Fellow, A. I. E. E.

Synopsis.—*Tables of Bessel functions of zero and higher orders are given for use in problems of skin effect and proximity effect in conductors carrying alternating currents. Formulas for deriving numerical values of the functions are given in the form of series for large and for small values of the argument. The series are complete with their general terms. The application of the tables to the calculation of the skin effect resistance ratio of an isolated tubular conductor is described and an example is given.*

* * * * *

THE behavior of alternating current in a round conductor or in groups of round conductors is calculated by means of Bessel functions. Such problems are usually known as skin effect and proximity effect problems. The division of current between conductors connected in parallel, (or in other words, the circulating currents in parallel conductors,) the distribution of current over the cross-section of the conductors, the watts loss in each conductor, the resistance drop and the reactance drop, are characteristics which are desired to be known and which can be calculated for round wires.

Such problems occur in electrical engineering where heavy alternating currents of more than about 1000 amperes at 60 cycles are involved. When it is remembered that generators for power stations sometimes have a rating of 5000 amperes or more, and that electric furnaces up to 50,000 amperes capacity are built, it is evident that these problems occur in practical engineering. Small conductors carrying currents at radio frequencies require calculations similar to those for large conductors carrying 60-cycle current.

In this paper is presented a collection of available numerical values of Bessel functions of argument $x\, i \sqrt{i}$, which are used in the classes of problems described. Bessel functions of the first and second kinds, of zero order and of higher orders, and for values of x up to 10, are included. Series are also given, some of them of new form, for calculating additional values.

*Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Complete copies upon request.

PHOTOELECTRIC TUBE COUNTS TRAFFIC PASSING THROUGH HUDSON TUNNEL

Every automobile passing through the Holland Tunnel under the Hudson River between New York and New Jersey is now registered at the exit by an electric traffic checker. The device works 24 hr. a day, never missing the count, which is recorded instantly upon a dial in the administration building of the Tunnel Commission at Varick and Canal Streets in New York City. The apparatus consists of a small floodlight mounted in an inclined position upon the overhead ironwork of the exit. A slender beam from the light falls upon a small circular window in a box placed beneath the sidewalk at the opposite side of the roadway. The box contains a sensitive photoelectric tube, an amplifying tube, and an electrical relay. When a vehicle passes, the beam is interrupted. The photoelectric tube is affected so that a slight electrical impulse results. This is amplified by the vacuum tube and fed to the relay, energizing a transmission circuit, the other end of which is in the commissioner's office. A dial there, actuated by the electric current, registers another figure in response to each impulse from the relay.—*Telephone and Telegraph Age.*

ILLUMINATION ITEMS

Submitted by

The Committee on Production and Application on Light

AVIATION LIGHTING

By L. C. Porter*

The American public is rapidly becoming air-minded, and the result is that aviation is advancing faster than any previous method of transportation. Like all other modes of travel, if aviation is to succeed commercially, operations must extend into the night. Night flying necessitates lighted airways and lighted airports. Great progress is being made along those lines. Guided by Government practise, the art of lighting is becoming standardized very rapidly.

The lighting of the airways is installed and maintained by the Government in much the same manner that lighthouses, buoys, etc., are operated. The principal lighting unit on the airway consists of a 24-in. rotating searchlight equipped with a 1000-watt Mazda lamp and producing a 5-deg. beam of about two million candlepower. The speed of rotation is six rev. per min. In the latest beacon an auxiliary lens is placed in the top of the beacon to produce an upward fan of light for an indication when a flier is directly above the beacon. The rotating beacons are supplemented by smaller fixed searchlights, trained up and down the course, which flash the number of the beacon. They are called "course lights."

There are also emergency landing fields along the airways, having illuminated wind cones, obstruction and approach boundary lights.

The lighting of the airports is generally a municipal job. There seem to be two general methods in vogue. One is by the use of a number of relatively small floodlights equipped with 1500- or 3000-watt lamps. These may be either grouped or distributed along two adjacent sides of the airports. The other method is the use of one or two very high-power field floodlights. There are three types of these in use. One consists of a large Fresnel type lens equipped with a 150-ampere high-intensity arc or a 10-kw. Mazda lamp.

Another type of unit that has proved very successful consists of two 10-kw. Mazda lamps backed by searchlight mirrors and equipped with lenses to spread the beam into fan shape over the field. The latest unit consists of a set of parabolic cylinder reflectors equipped with a number of 3-kw. Mazda lamps.

In addition to the main field floodlights, there are white boundary lights to outline the field; green lights to indicate the best direction of approach, red lights to mark obstructions, a rotating beacon and an illuminated wind indicator. Most fields also have floodlighted hangars, a ceiling projector and an illuminated sign.

*Engineering Department, Edison Lamp Works of the General Electric Company, Harrison, N. J.

The greatest hazard in flying today is fog. Many extravagant claims have been made on the fog penetrating ability of neon light. It is claimed to have some peculiar characteristic which other forms of red light do not possess. In this connection, it is interesting to note the conclusion reached by the U. S. Bureau of Standards after making a most exhaustive study of the relative merits of a neon beacon *vs.* a Mazda lamp equipped with a red color screen. We quote from the *Technical News Bulletin* of the Bureau of Standards, Nov. 1928, No. 139 as follows:

"Observations were made with the naked eye and with a photometric wedge. No differences sufficiently great to be detected by the methods used in this test were found between the visibility of light from a neon lamp and the light of the same color, candlepower, and horizontal distribution produced by an incandescent filament lamp with color screen.

"With regard to the comparison of the clear incandescent lamp and incandescent lamp with red color screen, the red filter does not increase the range under any weather conditions, but there is some evidence that the red filter does not reduce the range as much in foggy weather as it does in clear weather."

A great deal of interest has arisen in air marking signs to mark the airways and name the towns. Several systems are in use, *i. e.*, floodlighting, neon tubes, and exposed Mazda lamps. In this connection, the U. S. Department of Commerce, Airways Division, has just completed an exhaustive test on the relative legibility of various types of signs. We quote from their report.

"Illumination by direct light is the most effective owing to greater brilliance and hence greater attracting power. Markings illuminated in this manner are effective at night even though the color of the characters is obscured by dirt or snow.

"For outlining with incandescent lamps, not less than 10-watt sign lamps should be used and they should be spaced from 8 in. apart for 6-ft. letters to 12 in. apart for 12-ft. letters or larger. Unless there is a large amount of competing light in the vicinity of the marking, the 10-watt lamps give better legibility than lamps of higher wattage. In case it is desired to use colored lamps with a brilliance corresponding to the 10-watt clear sign lamps, 25-watt lamps should be used for green and red and 50-watt lamps for blue."

A very effective air making sign consisting of a big 100-ft. arrow made up of standard parts, has been perfected. Plans are under way to carry out a nation wide marking of the airways with signs of this type.

Several good articles on aviation lighting have appeared in the transaction of various engineering societies, and in the technical press, going into great detail in aviation lighting. In this article we have therefore only mentioned the latest developments.

LIGHT AND ARCHITECTURE

By A. L. Powell*

It is quite natural for new schools of thought in design, decoration, and architecture to originate in continental Europe. The atmosphere, background, and tradition of the larger cities are all conducive to this end. Within the last half century, or even since the beginning of the 20th century, our very habits of living have undergone remarkable changes. The mechanical element in the production of all sorts of objects has come to the foreground. Speed of transportation has greatly increased. With mass production, things formerly considered luxuries have become necessities and the spirit of the age such as to make a new school of architecture and decoration come into being. The recent war, demanding practically all the thought and energy of the entire world, made it impossible for even the artist to sit back and dream of his problems. After the close of the war there was a brief period of reconstruction, but by about 1924, clever minds began to evolve a new school of decoration. For want of a better name, this has been termed "art moderne."

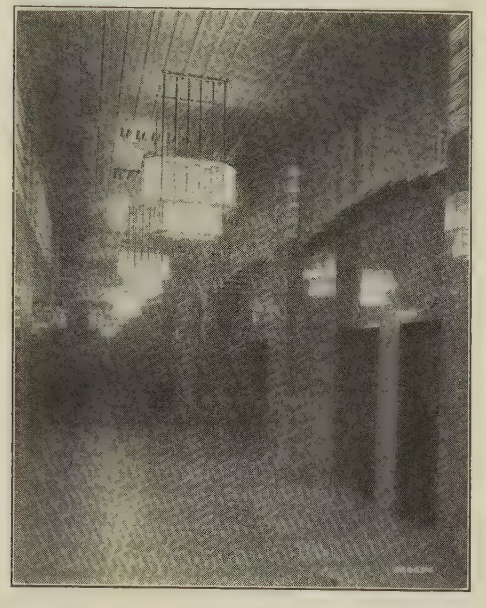

Fig. 1—The Entrance Corridor of One of the Newer New York Office Buildings

It is interesting to note how the decorative lines have been carried out in the luminaires. Even the very method of support bears little resemblance to the types which were familiar a few years ago

In the Paris Salon of 1924 were exhibited a few examples of this trend in design. The International Exposition of Modern Decorative and Industrial Art in Paris, 1925, was literally filled with further developments. From France, the idea extended to Germany, England, Italy, and other parts of Europe. Many delegates, artists, architects and designers from the United States at once saw the application of this unique treatment to American conditions and we now have some excellent examples in this country. For example, the sky-scraper is distinctly American in character and feeling, and this new school of decoration seems to have embodied in it very much of the same spirit.

Some of the original designs of the French were unquestionably extreme and did not appeal to our taste. Many of the German modifications are even more bizarre, but it may safely be said that most Americans who have adopted this treatment have done a most commendable job. They have to a great degree eliminated the ultra-fantastic element and created something distinct and adapted to our taste. They have grasped the fundamental principles and developed these along rational lines. Practically every new commercial building now being erected, or even contemplated, particularly in the vicinity of New York, has some of this modern treatment incorporated in it.

Lighting plays a very important part in "art moderne." Some of its very first applications were to luminaires or fixtures. The Germans have incorporated light in this new art to such a remarkable degree that they have coined a term "Licht Architektur" (light architecture) as applying to those structures where light is utilized in novel manners. At last we are seeing the lighting planned as a component part of the structure, or the luminaire carrying out in line and decoration the spirit expressed in the architecture.

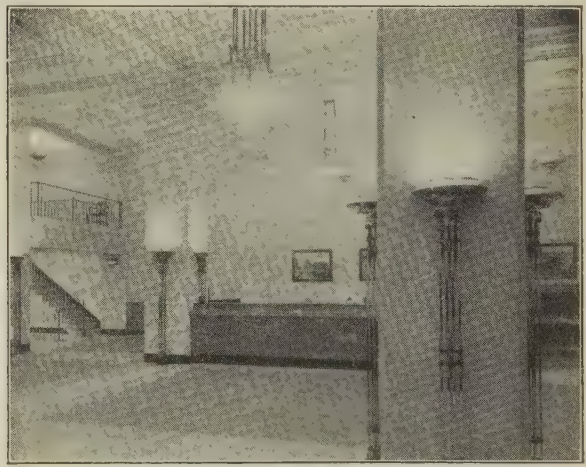

Fig. 2—A Bank Interior with Luminaires of Unique Designs Which Conceal All Lamps from View

These are almost entirely of glass and being of low brightness, are beautiful lighted ornaments. The real working illumination comes from large lamps in indirect reflectors on pedestals around each column

This movement is most encouraging to the lighting engineer, for he has been preaching for a long while that incandescent lamps are indeed radically new light sources and need not be handled in the traditional or classical manner. In the days of flame illuminants, it was necessary to have the light source at some distance from surrounding objects to prevent fire. It was necessary to take care of the products of combustion, to provide ventilation, and in the case of candles, to have some

*Research Laboratory, General Electric Company, Schenectady, New York.

means of catching the dripping wax. It is quite ridiculous to place Mazda lamps on the end of paper tubes and attempt to simulate candle lighting. It is almost as illogical to use chandeliers of the types designed for gas jets.

The incandescent lamp can be burned in any position;

Fig. 3—A Distinctive Store Interior with Glassware Made by the Famous French Artist, Rene Lalique

it can be entirely enclosed; it may be recessed in a wall pocket; it may be concealed within a structural member and its light emitted through diffusing or diffracting windows. There is literally no end to the manner in which it may be employed. The ingenious designer

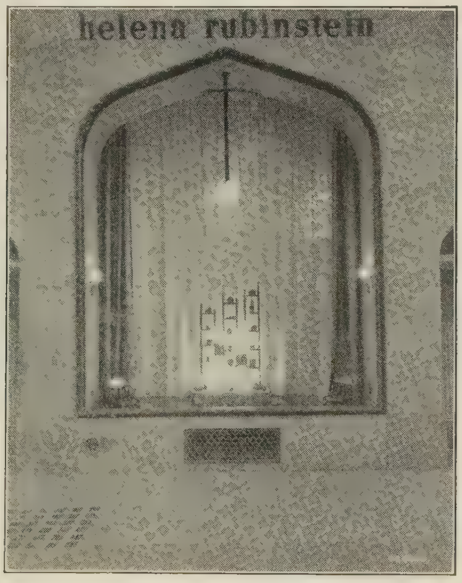

Fig. 4—One of the Newer Types of Show Windows Employing General Overhead Lighting Plus Some Fixtures of Low Brightness and Lighted Display Stands

may let his imagination run far afield and electric lighting will enable him to carry out his most imaginative scheme. This new art takes full advantage of the imagination and, while at present still in the embryonic or formative state, it has already produced numerous examples of truly unique ways of supplying artificial light. It is essentially a young man's movement. It will be difficult for the older designer, steeped in classical traditions, who all his life has been copying 18th and 19th century fixtures, to get this radically different

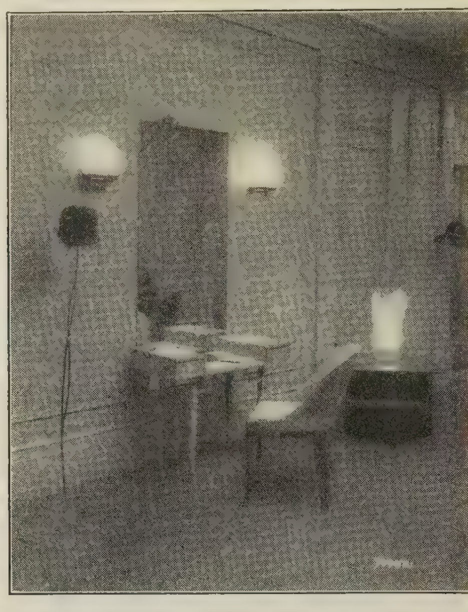

Fig. 5—A Corner in an Exclusive Millinery Shop Illustrating the Use of American Made Lighting Equipment Along Modernistic Lines

The designs are very simple, consisting of planes of frosted glass held by a wrought iron framework. The modern Mazda lamp does not need to be applied at the end of an imitation candlestick and should be used in a 20th century manner

point of view. Some of the examples are indeed extreme in character and unquestionably will not live. Most of them, however, have the germ of an advance and are

Fig. 6—Reading Room in the Panhellenic Bldg., 49th St. and 1st. Ave., New York City

to be commended. Out of the stress will come something of which we will be justly proud. We are seeing the beginning of a new school just as surely as Europe saw new ideas introduced at the Renaissance.

INSTITUTE AND RELATED ACTIVITIES

The Summer Convention at Swampscott

The activities of the A. I. E. E. Summer Convention at Swampscott, Mass., start simultaneously with the printing of this issue of the JOURNAL, and the detailed account of this meeting will therefore have to be deferred until the issuance of the August JOURNAL. The plans formulated by the Convention Committee for this occasion, however, have been so comprehensive that there can be no doubt that the traditional success of our Summer Conventions will be maintained. The completed program for the technical sessions is even fuller than usual, necessitating several parallel sessions; and the sports and entertainments offered are more than ample to occupy every moment available for recreation.

Pacific Coast Convention Papers Deal With Live Problems

A technical program which will deal with some of the most active problems of electrical engineering is being arranged for the Pacific Coast Convention of the Institute, which will be held September 3-6, at Santa Monica, California, with headquarters at the Hotel Miramar.

The subjects to be covered in the technical papers include several phases of transmission, insulator flashover, wood pole insulation strength, series synchronous condensers, system stability, transformers, high-voltage fuses, insulating oils, arcs, electrical conductivity, gas-filled tubes, radio interference, sound pictures, dial telephony, population forecasting, wind tunnel equipment, turbo-generators, a-c. networks.

The following are the title of papers which have been proposed; more information will be given in the August issue of the JOURNAL:

SUBJECTS PROPOSED FOR PACIFIC COAST CONVENTION

Radio Interference from Line Insulators.
Spray and Fog Tests on 220-Kv. Insulators.
The 60-Cycle Flashover of Long Suspension Insulator Strings.
Impulse Insulation Characteristics of Wood Pole Lines.
Recent Developments in the Theory of Electrical Conductivity.
Development of Insulating Oils.
Effect of Tank Color on Temperature of Transformers under Service Conditions.
Population as an Index to Electrical Development.
Flames from Electric Arcs.
Design Features That Make Large Turbine Generators Possible.
Effects of Surges on Transformer Windings.
An A-C. Low-Voltage Network without Network Protectors.
Development of Low-Current, High-Voltage Fuses.
Neon-Filled Tubes and Their Characteristics.
Electrical Control Features of Wind Tunnels.
The Electrical Engineering of Sound-Picture Systems.
Dial Telephone System Serving Small Communities of Southern California.
Parallel Operation of Transformers Whose Ratios of Transformation are Unequal.
Relation of System Connections and Apparatus to Stability.
Series Synchronous Condenser for Transmission-Line Regulation.

World Engineering Congress Program Progressing

Among the many papers dealing with electrical engineering progress in the United States, scheduled to be submitted by American delegates to the World Engineering Congress in Tokio next Fall, are "Extra High-Voltage Transmission," by J. P. Jollyman and E. R. Staffacher, "Interconnection of Electric Systems," by Farley Osgood, P. M. Downing, W. E. Mitchell, and E. C Stone, "Résumé of the Stability Problems as Applied to Long Distance Transmission of Power," by Charles Le G. Fortescue, "Remote Operating Supervision and Control of Electric Power Stations and Substations in the United States," by Chester Lichtenberg and Ferdinand Zogbaum, "Economic and Operating Considerations in Railroad Electrification in the United States," by Dugald C. Jackson, and "High-Tension Cable Specification and Design in America," by William A. Del Mar.

Other papers to be read by American delegates to the Congress are: "The Rapid Transit Subways of New York" by Robert Ridgway, "Municipal Engineering in the United States" by C E. Grunsky, "River and Harbor Engineering in the United States" by Edgar Jadwin, "Ventilation of Vehicular Tunnels" by Ole Singstead, "The World's Iron Ore Supply" by C. K. Leith, "Refrigeration in the Preservation of Food" by Harden F. Taylor, "Safety in Dam Construction" by Allen Hazen, "Development in the American Coal Industry, 1913-28" by George Otis Smith and F. G. Tryon, "Suspension Bridges" by Ralph Modjeski, and "Petroleum" by Mark L. Requa. Doctor F. B. Jewett, Doctor Elmer A. Sperry, Doctor W. C. Whitney and F. W. Peek, Jr. will also be contributors.

Arrangements for the transportation of American engineers and European delegations were announced June 29 by Maurice Holland, Executive Secretary of the American Committee of 80 engineers and scientists sponsoring participation of the United States in the Congress.

A second ship has been engaged to transport the official delegates from America and Europe, who with their families will number close to 300. The official ships, S. S. *President Jackson* of the Dollar Line and S. S. *Shmyo Maru* of the Nippon Yusen Kaisho Line will depart from San Francisco on October 10.

Engineering Experiment Station Record

The Engineering Experiment Station Record Summary for 1929 now available at $1 per copy by application to R. A. Seaton, Dean and Director, contains carefully prepared data on many live research projects, administration, organization, funds, employees, channels of publication, bulletins and circulars issued, and other data on engineering research at each of the land-grant colleges and universities in the United States.

From the table given it will noted that there are now 38 definitely organized engineering experiment stations in the land-grant colleges and universities; definite provision is made for engineering research in several additional land-grant institutions, and a total of $1,440,018 is available for engineering research in these institutions for 1928-29; 925 persons are engaged either full-time or part-time upon engineering research and that 1263 engineering research bulletins or circulars have been issued.

The record is published by the Engineering Experiment Station Committee of the Association of Land-Grant Colleges and Universities, data being submitted by the directors of the experiment stations and deans of engineering and rechecked by the deans and directors. It is, therefore, most complete and an accurate summary of engineering research in the land-grant colleges and universities that has yet been issued.

While this Summary has been issued primarily for the use of research workers in the engineering field it contains much material of interest and value to others engaged in engineering and educational work. Only a limited number of copies are available at the present time.

Harold B. Smith
President-Elect of the A. I. E. E.

Harold B. Smith, Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass., and Consulting Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1929, as announced at the Annual Meeting of the Institute held at Swampscott, Mass., June 25, during the annual Summer Convention of the A. I. E. E.

Professor Harold Babbitt Smith was born at Barre, Massachusetts, May 23, 1869. He was graduated from Cornell University with the degree of M. E. in Electrical Engineering in June 1891, but remained as graduate student until December 1891.

In January 1892 he was appointed Professor of Electrical Engineering in charge of the department at the University of Arkansas. Resigning from this position in December 1892, he became Head Designer and Electrical Engineer for the Elektron Manufacturing Company, Springfield, Mass. From September 1893 to June 1896 he was Director of the Department of Electrical Engineering at Purdue University. He has held his present position as Professor of Electrical Engineering and Director of the Department at Worcester Polytechnic Institute since 1896.

Professor Smith retained a connection with the Elektron Manufacturing Company as consulting engineer until 1902, and did consulting work for several other organizations at various times. Since 1905 he has served as a consulting engineer for the Westinghouse Electric and Manufacturing Company.

He was Chairman of the International Group, Jury of Awards in Electrical Engineering at the St. Louis Exposition in 1904. During the years 1917-19, he was an associate member of the Naval Consulting Board and consultant of the Special Board of the Navy on Anti-Submarine Work.

Harold B. Smith

He has been a pioneer in the development of high-voltage power transmission systems and equipment, has carried on many researches involving advanced conceptions of dielectric phenomena and stress distribution, and holds numerous patents. He has contributed many papers to the transactions of the societies and other engineering publications.

Professor Smith's Institute activities are as follows: Associate 1891; Member 1901; Fellow 1913; Director 1920-24; Vice-President 1924-26; Chairman of Sections Committee 1924-27; and member at various times of the Coordination Education, Electrophysics, Law, Instruments and Measurements, Sections, Student Branches, Edison Medal, Research, Meetings and Papers, and a number of special committees. He is at present Chairman of the Committee on Code of Principles of Professional Conduct.

His other memberships include American Society of Mechanical Engineers (Member), Institution of Electrical Engineers (Great Britain), Society for the Promotion of Engineering Education, American Association for the Advancement of Science, Sigma Xi, and Tau Beta Pi.

Engineers to Award Their First Welfare Medal

At some time during the current year there will be presented by the American Association of Engineers, the first Clausen Medal, of which subsequent annual awards will be made to the engineer who, during the preceding year, "has accomplished distinguished service in the welfare cause —social or economic or both." The movement is sponsored by H. A. Wagner, a national director of the Association, and this year's committee of judges of award is composed of such men as G. M. Butler, Dean and Director of Engineering University of Arizona; L. W. Baldwin, President of the Missouri Pacific Lines; J. W. Thomas, Vice-President of the Firestone Tire and Rubber Company; C. F. Kettering, General Director of the General Motors Research Laboratories; Rufus B. von Kleinsmid, President of the University of Southern California; Michael I. Pupin, Research Laboratory Department of Physics, Columbia University; A. E. Morgan, President of Antioch College; W. L. Saunders, Chairman of the Board, Ingersol-Rand, New York; G. C. Warren of Warren Brothers Company, Boston, and A. N. Talbot, Professor Emeritus, College of Engineering, University of Illinois. The medal is named in compliment of Henry W. Clausen, of Chicago, who has given the Association such commendable service for the past 15 years in various executive capacities. It bears the inscription "Award in recognition of a signal public service. Designed to mark the

entrance of the American Association of Engineers into the field of welfare."

The Faraday Medal to Doctor Semenza

In April 1929, Doctor Guido Semenza, Local Honorary Secretary of the Institute, Milan, Italy, was made the recipient of the Farraday Medal, an honor of outstanding scientific distinction, conferred by the Institution of Electrical Engineers of Great Britain.

Guido Semenza was born December 19, 1868 in London, but of Italian parentage. His father was a prominent patriot during the period of the independent wars, and was a great friend of Mazzini and Garibaldi; he also helped materially in the revolutionary movements against the oppressors of the people of Italy. Guido, as a child, returned to Italy with his parents, where his early education and classical studies began, and in 1893 he received his degree as industrial engineer at the Politechnic School in Milan. Subsequently he received another degree in electrical engineering at the Institute Montefiore in Liege. The following year he became associated with the Edison Company in Milan, when it was starting the study of the Paderno plant, which was the pioneer hydroelectric plant in Europe. Here he assumed the supervision of the electrotechnical construction and also projected and directed the construction of the high-tension transmission line to Milan. He remained with the company until 1917 as Chief Electrical Engineer.

During his connection with the Edison Company, his services as a consulting engineer were very often sought by other companies and he became one of the principal consulting engineers of his country. He has also often been called upon in a consulting capacity by companies in foreign countries, principally in Zurich, Clermont Ferrand, London, Brussels, Odessa, Detroit and in various places in Brazil. With the assent of the managers of the Edison Company, he was called in 1904 to direct the activities of the Societa Alta Italia. He remained with the company as Manager until the telephone systems were taken over by the government in 1907. During this time he also served as a member of the Board of Directors of many Electrical Companies. In 1923 he succeeded in enlisting the necessary support and reorganized the company known as the C. G. S. (formerly Olivetti), manufacturing electrical instruments. He became its President and in a very few years it reached a high degree of prosperity.

He was one of the founders of the A. E. I., of which from 1915 to 1917 he was President, and during his incumbency, notwithstanding the difficulties of the war, the Association developed greatly. He was also one of the founders of the I. E. C., to which, since its inception, he has given generously of his time and advice. In this connection, he has been for many years President of the Italian Electrotechnical Committee and in such position has maintained a very active Italian participation in the I. E. C. In 1923 he was elected President of the I. E. C. and served in that capacity to September 1927. He entered actively and enthusiastically into the work of the Commission and developed its activities in many new fields. During his presidency, meetings were held at The Hague, New York, and Bellagio.

When the Italian Government decided to undertake the study of a general program for the develcpment of the telephone system, he was called upon to preside over the commission which was appointed to consider and formulate a program. The plan decided upon by this commission was adopted, and the development of the telephone system in Italy carried out in accordance with its recommendations. From 1919 to 1922 he was invited to become a Member of the Second Section of the Superior Council of the Public Works Department in Italy, which undertook a study of the problems of electric traction. His work in this council led the state railways to study the traction program from a broader point of view. During the war he was President of the Receiving Commission which had supervision over the production of shells by private industry. In the year 1922 he was elected President of the National Scientific Technical Committee and continued as its President until 1928, at which time the "Consiglio Nazionale delle Ricerche" was organized, the activities of the National Committee being absorbed by the new organization.

Doctor Semenza organized the Italian Electrical Exhibition at Marseille in 1906; he was also Commissioner General for Italy at the Exhibition of "White Coal" (energy generated by Alpine streams) and the Tourist Organization at Grenoble in 1925.

In 1921 he acted as President of the Commission sent to the United States by a group of electrical societies and financial interests to study the most recent electrical developments and to endeavor to interest American capital in Italian enterprises. He has also taken an active part in numerous international congresses, such as the First World Power Conference and la Conference des Grands Reseaux. He is Honorary President of the I. E. C., Vice-President of the International Commission on Illumination and of the Conference des Grands Reseaux, and for many years has been Honorary Secretary for Italy of the A. I. E. E. and of the I. E. E.

Doctor Semenza has published many original scientific studies, among them the extension given by him to the Kelvin Law for the calculation of conductors, graphical tables for overhead line construction, many studies on towers for transmission lines, and he was the first to propose the use of elastic supports. He has also given much study to the problems of insulation. The insulator used in the Paderno plant in 1898, which was designed by him, is considered today one of the best among pin type insulators. He also gave his active help and advice in connection with the renewal of the electrical and mechanical plants in the Scala Theatre in Milan. In 1924 he was invited to read the XV Kelvin Lecture before the I. E. E. in London.

STANDARDS

Electrical Definitions—Revised Report

Report No. 2 in the A. I. E. E. Standard's series was issued in August 1927. This report was made up of all the definitions appearing in the approved sections of the A. I. E. E. Standards of that date. It was issued to obtain criticisms and suggestions and if possible to eliminate inconsistencies. In a number of cases definitions of the same thing had developed, varying only slightly in wording. Such differences will unquestionably be necessary in some instances due to varying applications but in most cases can be eliminated through agreement of the committees having the standards affected in hand. A new report dated June 1929 is now available in which part of such coordination work has been included. The new report has also been carefully cross-indexed and brought up to date by the insertion of definitions from Standards approved since original date of publication. Copies of this new Report No. 2 may be obtained without charge by writing, H. E. Farrer, Secretary, Standards Committee, A. I. E. E., to whom all criticisms or suggestions should also be addressed.

Constant Current Transformers—A New Report

Report No. 12 on A. I. E. E. Standards for Constant Current Transformers is now available. In accordance with our regular practise with all proposed A. I. E. E. Standards this is issued with a view to obtaining the opinions, criticisms and suggestions, of as many interested persons as possible. This report was developed by a subcommittee of the Electrical Machinery Comittee of the Institute. These tentative Standards apply only to constant current transformers. Other types of transformers are covered by Section 13, "Transformers, Induction Regulators

and Reactors," and Section 14, "Instrument Transformers," both approved A. I. E. E. Standards. The new report contains definitions, rating requirements, temperature limitations and methods of making the temperature test, efficiency and losses, dielectric test, insulation resistance, lead markings for transformers, recommendations for operation. Copies of Report No. 12 can be obtained without charge by writing the Secretary of the Standards Committee at A. I. E. E. headquarters.

Switchboards and Switching Equipment for Power and Light

A Report No. 27, on proposed Standards for Switchboards and Switching Equipment for Power and Light, developed by a subcommittee of the Standards Committee, is now available for criticisms and suggestions. This report covers proposed Standards for switchboards and switching equipment not specifically covered elsewhere as apparatus. The Standards do not apply to industrial control equipment or communication switchboards and switching equipment. The following listing shows the general subjects covered in the report: Service Conditions, definitions, rating, temperature limitations, tests, name plates. Copies of this report can be obtained without charge by writing the Secretary of the Standards Committee at A. I. E. E. headquarters.

Abbreviations for Scientific and Engineering Terms

A Subcommittee on Abbreviations of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations has been working on the development of American Standards for abbreviations for scientific and engineering terms. The work of the subcommittee has now reached the point where it is possible to print their report as the proposed Tentative American Standard. The American Society of Mechanical Engineers, one of the joint sponsors with the Institute and three other groups, has issued the report in page proof form for the purpose of criticism and comment. Abbreviations of electrical terms form a part of the report. Probably the most notable feature of the proposed abbreviations is the omission of period except where the abbreviation forms a complete word, as (arm. for armature). The Sectional Committee has made the following distinction between symbols and abbreviations: A symbol is a letter or sign used in a formula as a substitute for any numerical value. A shortened expression for a name or a unit is an abbreviation and not a symbol.

The Subcommittee on Abbreviations has formulated the following fundamental rules for formation and use:

1. Abbreviations should be used sparingly in text and with regard to the context and to the training of the reader. Terms denoting units of measure are abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings, and text for special purposes, the use of abbreviations is governed by the desirability of conserving space.

2. Do not begin a sentence with a numeral followed by an abbreviation.

3. Avoid capitals in abbreviations except in words normally capitalized.

4. Hyphenated compound words call for hyphenated abbreviations; thus "hp-hr"

5. With but few exceptions of abbreviations in common usage, the singular only is used; thus "in." for "inches," not "ins.;" but No., Nos., Fig., Figs.

6. Short words such as ton, day, and mile are spelled out.

7. Do not use abbreviations where the meaning will not be clear. In case of doubt, spell out.

8. Do not use conventional signs for abbreviations in text; thus per, not/; lb. not #; in., not ″. Such signs are used sparingly in tables and similar places for conserving space.

9. The Committee endorses the movement which was begun by the International Committee on Weights and Measures in omitting the period in abbreviations of metric units and further endorses the growing tendency toward the omission in abbreviations of other origin. In the interests of economy and the elimination of waste the Sub-Committee recommends the elimination of the period in all cases except a few where such an omission results in an English word. Exceptions to this practise will be found in a few mathematical and chemical terms, such as sin, tan, log, Be, etc.

10. Do not space the letters of such abbreviations as ASME (not A S M E).

11. In text, do not use the exponents for the abbreviations of square and cube nor the negative exponents for terms involving per. The superior figures are usually not available on the keyboards of typesetting and linotype machines and composition is therefore delayed. There is also the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and are sometimes difficult to avoid in text.

Report of Committee of Tellers on Election of Officers

To the President

American Institute of Electrical Engineers

Dear Sir:

This Committee has canvassed the ballots cast for the election of Institute officers for the year 1929-30, and reports as follows:

Total number of ballot envelopes received		5077
Ballots rejected, in accordance with Art. VI, Secs. 32 and 34 of the Constitution:		
From members in arrears for dues for year ending May 1, 1929	137	
Received in envelope unmarked by identifying signature	48	
Received in improper envelope	124	
Received after May 1, 1929	19	
Leaving as valid ballots		4749

These 4749 valid ballots were counted, and the result is shown as follows:

For President

Harold B. Smith	4591
Blank	158

For Vice-Presidents

District		
No. 2 *Middle Eastern*		
	E. C. Stone	4622
	Blank	127
No. 4 *Southern*		
	W. S. Rodman	4597
	Blank	152
No. 6 *North Central*		
	Herbert S. Evans	4595
	Blank	154
No. 8 *Pacific*		
	C. E. Fleager	4597
	Blank	152
No. 10 *Canadian*		
	C. E. Sisson	4595
	Blank	154

For Directors

J. E. Kearns	4656
W. S. Lee	4660
C. E. Stephens	4660
Blanks	271

For National Treasurer

George A. Hamilton	4622
Blank	127

Respectfully submitted

W. E. Coover, *Chairman*
Alek Johnson
R. R. Kime
W. C. F. Farwell per G. F. Fowler
J. T. Wells
R. A. Rich

Committee of Tellers.

Date May 14, 1929

AMERICAN ENGINEERING COUNCIL

A. E. C. APPOINTS COMMUNICATIONS COMMITTEE

To Study Couzens Bill for Regulation of the Transmission of Intelligence by Wire or Wireless

With the approval of the Executive Committee, President Berresford has announced the appointment of A. E. C.'s Committee on Communication, as follows: E. F. Wendt, Chairman; O. H. Caldwell; C. B. Hawley; Dean Dexter S. Kimball; Professor Frank A. Scott.

Shortly after the beginning of the special session of the 71st Congress, Senator Couzens introduced S. 6, April 18, 1929, which provides for the regulation of the transmission of intelligence by wire or wireless. The purpose of this bill is to regulate all forms of interstate and foreign radio transmission communications within the United States, its territories and possessions, this to be accomplished through a commission composed of five, representing five territories.

On June 4, Senator Couzens proposed an amendment to his original bill, changing the Commission's name from Commission on Communications to Commission on Communications and Power. Such a Commission would take over most of the duties of the present Federal Power Commission.

It is contemplated that the special committee of American Engineering Council on Communications will render its report prior to the meeting of the Administrative Board in October.

QUESTIONS DISCUSSED AT MEETING OF THE ADMINISTRATIVE BOARD

Among the many items handled at the meeting of the Council's Administrative Board May 24-25, in Washington, D. C., notice of which appeared in the June issue of the Journal page 484 were the Report of the Treasurer; Approval of the Revised Budget; Membership and Representation of American Society of Civil Engineers; Report of Committee on Flood Control; Appropriations for U. S. Geological Survey; Topographic Mapping; Government Reorganization; L'Enfant Memorial; Functional Outline of Work of Committee on Engineering and Allied Technical Professions; State Engineering Councils; Amendment to the Federal Constitution; Legislation Relative to Water Resources; and World Engineering Congress.

The Executive Committee recommended to the Administrative Board that Council exercise its influence to secure larger appropriations for the prosecution of the topographic mapping of the United States. This recommendation was approved by the Administrative Board.

Approximately thirty patriotic organizations have endorsed the movement to have erected here in Washington, D. C. a memorial monument to Major Charles Pierre L'Enfant. Major L'Enfant was one of the early American patriots of the Revolutionary War. He was a distinguished French engineer who offered his services and actually joined the cause of the thirteen colonists several months prior to his distinguished compatriot, Lafayette. Major L'Enfant is perhaps best known because he was commissioned by General George Washington and actually designed and laid out our National Capital City, Washington. In the proposed plans for the beautification of Washington the original designs of Major L'Enfant are to be followed in nearly all respects.

COUNCIL APPOINTS COMMITTEE ON ENGINEERING AND ALLIED TECHNICAL PROFESSIONS

The Administrative Board of American Engineering Council meeting in Washington, D. C., May 24, approved the personnel of the committee authorized by Council's Constitution. This committee is known as the Committee on Engineering and Allied Technical Professions, and will be constituted as follows: H. C. Morris, retired mining engineer of Washington, D. C., Chairman. Conrad N. Lauer, representing The American Society of Mechanical Engineers; H. A. Kidder, representing the American Institute of Electrical Engineers. (He will serve as Chairman of a similar committee for the Institute at such time as it is authorized); A. B. McDaniels, representing the American Society of Civil Engineers; and L. W. Wallace, Executive Secretary, American Engineering Council is ex-officio a member of the committee.

This Committee was formed to enable the Council to enter upon a program designed to improve the general status of the engineering profession. The program as now contemplated partakes of the following character: (1) Collect, tabulate, analyze and disseminate information concerning the earnings of engineers, such information to be so classified as to give a clear conception of the earnings of engineers in the several branches of the profession and also in various lines of endeavor such as Federal, State, and municipal employment. (2) For the purpose of suitable comparisons, information will be obtained in so far as possible relating to the earnings of other professional men. (3) To ascertain the status of the profession as measured by appropriate standards. (4) To determine the major trends of the profession. (5) To disseminate the facts ascertained. This dissemination is to be directed towards two different audiences; namely, (a) engineers; (b) the public. (6) Classification:—A determination or classification in which each type of engineer belongs, and a statement of the qualifications requisite to this classification. This is particularly needed in the Federal government service. (7) Registration of engineers:—Registration of engineers prevails in some twenty states. This movement has had no guidance on the part of any major fraction of the profession. However, because of existing registration laws no adequate plan can be projected relating to the economic and professional status of the engineer without giving due consideration to the influences and trends of registration. (8) Technical Education:—This item is listed for the purpose of raising the query as to whether or not the profession has any responsibility with reference to technical education. (9) By-Paths:—Such a broad gaged survey as is contemplated will not fail to bring to light certain corollary questions which will of necessity have to be pursued to some degree in order to get that breadth of comprehension necessary to an inclusive judgment and action. (10) Objectives for the profession:—On the basis of the information comprehended in the foregoing items, there should be an opportunity to set up certain forward looking and comprehensive objectives for the profession. Engineers are presumed to be analyzers and planners. It is therefore logical to believe that by analyzing the profession they would be able to formulate some major objectives for the profession to endeavor to realize in the years ahead. (11) Expert guidance:—It is contemplated as a result of the survey the Council will arrive at that position where it can give expert guidance to matters affecting the profession or branches thereof in local and national situations. What is contemplated here can best be illustrated by a specific example. Some months ago there arose a critical relationship between the engineers employed by the municipalities of New York and

Chicago largely relating to the salaries paid to such men. The Council hopes, as a result of the survey, to be able, when such situations arise, to send a man thoroughly versed in such matters to the locality involved for the purpose of counseling with and supplying facts to any local committee, thereby enabling such committee to be more successful in its negotiations.

MEETING OF SECRETARIES OF ENGINEERING SOCIETIES

The conference of Secretaries of Engineering Societies has been sponsored by American Engineering Council. The fourth such conference was held June 6, 1929, in Chicago.

There are many problems which all engineering societies have in common, and a meeting approximately every two years of those compelled to study and obtain some solution to these problems has been found most helpful. Among the questions discussed at the recent meeting was the standardization of forms, and procedure in effecting transfers of engineering society memberships; the matter of the adoption of standards and acceptable definitions for the designation of different grades in engineering societies was given considerable discussion.

Mr. Charles E. Billin, Secretary, Engineers Club of Philadelphia, presented an able discussion on the subject of Participation of Engineers in Civic Life of the Community.

FLOOD CONTROL OF MISSISSIPPI

Following the report of its Flood Control Committee the Administrative Board of Council, composed of Gardner S. Williams, Chairman, Baxter L. Brown, John R. Freeman, and Arthur E. Morgan, meeting in Washington, May 24, endorsed the report and recommended that a board of review consisting of non-partisan and competent civilian engineers be appointed with authority to develop the best possible solution of the Mississippi Flood Control Problem.

The Flood Control Committee represents several sections of the country and has given extensive study to the questions involved.

The Flood Control Act of 1928 provides for an expenditure in excess of $300,000,000. Many witnesses who appeared before the Flood Control Committee of the House predicted that the present plan which is being carried into execution is inadequate and may result in a disaster as great as that which occurred in 1927. In 1926 a report of the Chief of Engineers, U. S. A., stated that the valley was safe from floods.

The professional engineers through their duly constituted representatives, American Engineering Council, have continuously warned the nation of the inadequacy of the present plans for flood control on the Mississippi, and the danger involved in executing them.

Following a visit by a non-partisan delegation of the Senate and House of Representatives, Secy. of War Good has temporarily suspended action on the most controversial features of the present plan. Pres. Hoover has referred the matter to the Attorney General for a decision as to legal action permitted him as Executive of the Nation. Thus far, contracts for the proposed floodway levees in Missouri and the Boeuf Basin have not been let. It is expected that the Attorney General's decision will be that legally President Hoover is bound by the Flood Control Act of 1928 and the executive decisions of his predecessor, Mr. Coolidge, to the extent that he cannot delay or prevent the execution of the present authorized flood control plans without additional Congressional authority.

Senator Lynn Frazier of North Dakota has also introduced Senate Res. 69, the closing paragraphs of which are in part as follows:

"Resolved, That there is hereby established a board to be known as the Senate Mississippi Engineering Advisory Board, which shall be appointed, acting jointly, by the chairmen of the Committees on Commerce, Interstate Commerce, and Agriculture and Forestry; said chairmen shall have the authority to fix the compensation of the members of said board and to remove or replace at any time a member thereof. The said board shall submit a report to each of the said committees, and each committee shall transmit to the Senate the said report with their findings thereon.

"The said board shall be composed of eleven members who shall be nominated as follows: One, a financial economist, by the President of the Senate; two Army engineers by the chairman of the Committee on Interstate Commerce; two civilian engineers by the chairman of the Committee on Agriculture and Forestry; two civilian engineers by the American Society of Civil Engineers; and two civilian engineers by the American Society of Mechanical Engineers.

"The eleven members shall be qualified as follows: One member shall be an expert financial economist; two shall be Army engineers; and eight, each of whom shall be a distinguished civilian engineer of great attainment and experience, to be selected from as many of the following engineering classifications as practicable; Civil, mechanical, electrical, contracting, structural concrete, foundation, locks, dams, dredging, hydraulic, or marine construction.

One of the proposals which any review board studying the Mississippi Flood Control Problem would be expected to investigate, is the so-called "Riker spillway project," illustrated model of which is now on display in the basement of the Senate Office Building.

CENSUS BILL TO PASS

The Constitution of the United States requires a census every ten years for the purpose of re-apportioning the membership of the House of Representatives. Although the census has been taken every ten years, the House of Representatives was not re-apportioned after the 1920 census. The technical and political reasons assigned for the failure of Congress to comply with this Constitutional requirement are numerous, but the outstanding fact seems to be that in the last twenty years the large cities and industrial centers have gained very rapidly in population, while the rural sections of the country have gained only slightly. Many of the Members of Congress from states thus adversely affected by a reapportionment have opposed and thus far prevented a reapportionment being made.

According to the present legislation, the fifteenth and subsequent censuses will be restricted to population, agriculture, irrigation, drainage, distribution, unemployment, and mines, all subjects of vital concern to the engineering profession.

Among the chief differences in the bills as passed by the two Houses were the following: The Senate provided for a census of radio sets. The House struck out this provision. In conference the Senate accepted the amendment.

One of the most constructive features of the present census bill is the provision for the reapportionment of the House of Representatives automatically in accordance with the method used in the last preceding apportionment, leaving the total membership of the House of Representatives at its present figure of 435 members. The President is also instructed by this measure to report to Congress the apportionment that would result by the method used in the last preceding apportionment by the method known "as the method of major fractions," and by the method known as "the method of equal proportions."

The bill also provides that if the Congress to which the President's statement is transmitted fails to pass a reapportionment law, then each state shall be entitled to the number of representatives shown in the statement, based on the method used in the last apportionment until an apportionment law is enacted.

Professional and technical men familiar with the Constitution will view with regret the fact that Congress has not seen fit to adopt the scientifically correct and mathematically demonstrated method of reapportionment known as "equal proportions." For political reasons it was not possible to secure the enactment requiring the use of this method.

The administration and execution of the coming census will be under the Director of the Bureau of Census, Dr. William M. Steuart. His assistant is Dr. Joseph A. Hill. The heads of the various departments are as follows:

Population, Leon E. Truesdell: *Agriculture, Cotton and Tobacco*, William L. Austin: *Manufactures*, LaVerne Beales: *Financial Statistics of States and Cities*, Starke M. Grogan: *Vital Statistics*, Doctor T. E. Murphy: *Tabulation*, William B. Cragg; and *Geographer*, Clarence E. Batschelet.

Discussion at Dallas Regional Meeting

A summarized report of the discussion at the technical sessions of the Dallas Regional Meeting held May 7-9 is given in the following paragraphs.

A complete record of the discussions will be published with the respective papers in the TRANSACTIONS.

A report on other features of this meeting was published in the June issue of the JOURNAL.

POWER SESSION

Developments in Network Systems and Equipment, T. J. Brosnan and Ralph Kelly.

Standard-Voltage A-C. Network, John Oram.

Automatic Reclosing of High-Voltage Circuits, E. W. Robinson and S. J. Spurgeon.

In discussing the first two papers F. E. Johnson emphasized the difficulty of selecting proper fuses for networks. He advocated that the fuse should be of such size that it will give relief on primary cable faults rather than secondary cable faults.

R. J. Wensley, speaking on the last paper, pointed out that automatic reclosing equipment was in use as early as 1916. He mentioned that the advantages of simple d-c. closing solenoids may be enjoyed where only a-c. supply is available by employing small copper-oxide rectifiers to give the direct current.

SECOND TECHNICAL SESSION

Bare-Wire Overhead Distribution Practise, M. C. Miller.

Interconnection in the Southwest, G. A. Mills.

Electrification of Oil Pipe Lines in the Southwest, D. H. Levy.

Selective Remote Metering Equipment, R. J. Wensley.

In connection with Mr. Miller's paper, G. A. Mills stated that his company prefers to use weatherproof wire for the mechanical separation which it affords. He stated that his company is experimenting with a lead oxide coating over the weatherproof insulation, which coating has been proposed as a protection against deterioration of the insulation. J. B. Thomas stated that his company has had four year's experience with bare wire and that both installation and maintenance costs are lower than with weatherproof wire.

Commenting on Mr. Mills' paper, R. J. Wensley enumerated some of the engineering problems that arise on interconnected systems, such as voltage control in transformers, stability, quick excitation, relaying and communication.

In answer to questions regarding the use of synchronous and wound-rotor induction motors in oil pip-line pumping, D. H. Levy pointed out an important disadvantage of these two motors; namely, that they have brushes which may spark and cause explosions of the oil vapor which is often present. Enclosure of the motor in a separate room has several disadvantages he said.

THIRD TECHNICAL SESSION

Progress in Lightning Research, F. W. Peek, Jr.

Lightning Studies of Transformers by the Cathode Ray Oscillograph, F. F. Brand and K. K. Palueff.

Flying-Field and Airway Lighting, H. R. Ogden.

Electrical Features of the New Kansas City Water Works Plant, A. L. Maillard.

J. F. Peters, in discussing the second paper of this session, stated that the physical proportions of a transformer winding have very much to do with the voltage distribution and that with windings of the correct proportions the voltage distribution is uniform for the impulses which might produce dangerous oscillation.

There was further discussion by D. W. Roper, Edward Beck, and J. H. Cox on the work now being done to determine the nature of the surges caused by lightning on transmission and distribution lines.

FOURTH TECHNICAL SESSION

Meeting Long Distance Telephone Problems in the Southwest, H. R. Fritz and H. P. Lawther.

Railway Train Signal Practise, P. M. Gault.

Telephone Transmission Networks, T. E. Shea and C. E. Lane.

Program Transmission over Telephone Circuits for National Broadcasting, F. A. Cowan.

In answer to questions on his paper Mr. Gault stated that semaphore signals are becoming obsolete on many railroads. The first cost and maintenance expense he said are higher for the semaphore than for the light signals.

In discussing the telephone papers F. A. Cowan brought up the point of resistance noise in communication circuits which is caused by the thermal agitation of electrons within a conductor. This resistance noise he said has to be considered as its level must not be so high as to interfere with the signal. Other facts in connection with the history and the extent of communication systems were discussed by S. P. Grace, J. W. Creasy, C. W. Mier, E. T. Mahood, W. O. Pennell, and A. B. Covey.

Muscle Shoals Again Before Congress

On May 28, Senator Norris of Nebraska introduced S. J. Res. 49 which provides for the operation of Muscle Shoals, for the experimental production of nitrogen and for the sale of surplus power there generated. The following day, the Senate Committee on Agriculture and Forestry, by vote of 13 to 0, ordered a favorable report on this legislation.

This action was taken after Senator Norris had explained that the resolution is practically identical with the joint legislation passed by both Houses during the last Congress and which was pocket-vetoed by President Coolidge.

An appropriation of $10,000,000 would be authorized by this resolution to start operations, and expenses thereafter would be met by revenues derived from surplus power.

Award of George Montefiore Levi Foundation

The Jury of the first triennial meeting of the FOUNDATION GEORGE MONTEFIORE LEVI held at Liege September 21, 1911, has awarded to Mr. Bela Gati, Chief Engineer of Telegraphs, Budapest, a prize of three thousand francs, for his memoirs entitled:

a. Researches on the Microphone and on the Telephone at Many Thousand Kilometers Distance; and

b. Telephone Relays.

The Jury is composed of: Mr. Eric Gerard, President, Messrs. Banneux, Boucherot, Count Cicogna, de Bast, Kapp, Kennelly, Kittler, Libert and Roosen, members; Mr. L'Hoest, Secretary General.

Mr. Bela Gati was elected an Associate of the Institute in 1925.

PERSONAL MENTION

W. J. MOULTON-REDWOOD, previously Plant Engineer for the General Motors New Zealand Ltd. is now with The Canadian National Railways in the capacity of Engineer Computor in the Valuation Department.

E. FINLEY CARTER has resigned from the General Electric Company, Schenectady, where he was employed in the Radio Engineering Department in charge of special developments, to direct radio frequency developments for the Mutual Research Corporation, located at Long Island City.

O. H. ESCHHOLZ has been appointed manager of the Patent Department of the Westinghouse Electric and Manufacturing Company, succeeding O. S. Schairer, who resigned to accept a similar position with the Radio Corporation of America. Mr. Eschholz's headquarters will be at the company's East Pittsburgh works.

O. C. CORDES has recently severed his connections with the

Castanea Paper Company, and New York and Pennsylvania Company, where he was employed as Research Engineer, to become General Industrial Engineer for the Engineering Division of the Westinghouse Electric and Manufacturing Company's Middle Atlantic District, Philadelphia, Pa.

Hadley F. Freeman, of Smith and Freeman, patent attorneys, 1310 Hanna Building, Cleveland, Ohio, has opened a branch office at 907 Otis Building, Chicago, under the name of Freeman and Sweet. Mr. Freeman will act as counsel for the Chicago office and conduct its litigation, but will remain resident here, and the Chicago office will be in charge of Mr. Sweet.

Mortimer Silverman, of Brookline, assistant to the president of the Boston and Maine Railroad, has resigned to become Chief Engineer and Assistant to the President of the United Merchants' and Manufacturers' Corp., and in his new position will again be associated with Homer Loring, former Chairman of the Boston and Maine with whom he was formerly connected for 17 years.

D. McFarlan Moore, Fellow of the A. I. E. E. and Past Vice-President of the Illuminating Engineering Society well known as one of the earliest pioneers in gaseous conduction, and inventor of the television lamp, has been elected a member of the Lehigh Chapter of the Society of the Sigma XI.

Mr. Moore also recently addressed the Electrochemical Department of Columbia University.

Arthur W. Gray, by whom the Thermal Expansion Laboratory of the Bureau of Standards was established and who originated important methods and apparatus that are still in use there, has joined the staff of The Brown Instrument Company as Associate Director of Research, where he will be engaged mainly in the development of scientific and industrial instruments. For this work Dr. Gray is well fitted by his long training and experience.

Parker Hayward Daggett, formerly Professor of Electrical Engineering at the University of North Carolina has been elected Dean of the College of Engineering, Rutgers University, New Jersey. Professor Daggett has been President of the North Carolina Society of Engineers, and was active in preliminary plans for the North Carolina Section of the A. I. E. E. which was organized May 2, 1929, in accordance with authority granted by the Board of Directors on March 21.

H. Speight of the Westinghouse Electric and Manufacturing Company has been appointed to the office of Section Engineer in charge of electrochemical and electrometallurgical work in the company's General Engineering Department, East Pittsburgh, Penn., effective May 1, 1929. Following his experience in the public utility field, Mr. Speight for two and one-half years was manager of an electrical contracting company in Liverpool.

Frank A. Merrick, an executive of the electrical industry who has served in the United States, Canada, and Great Britain, was recently elected President of the Westinghouse Electric and Manufacturing Company. He succeeds E. M. Herr, President since 1911, whose resignation was tendered that he might go on an extended vacation necessitated by his present state of health.

Mr. Merrick advances to president from the position of vice-president and general manager. He joined the Institute as an Associate in 1907.

John F. Peters, prominent consulting engineer of the Westinghouse Electric and Manufacturing Company, was awarded the Longstreth Medal for the invention of the klydonograph—the only simple device in the world for recording the effect of lightning as it strikes a transmission line. The award was made on May 15 at the Medal Meeting of the Franklin Institute in Philadelphia. In 1925 Mr. Peters was appointed to his present position of Consulting Engineer for the entire Westinghouse organization. Today he is credited over 30 patented inventions.

Lewis Taylor Robinson, Engineer-in-Charge of the General Engineering Laboratory of the General Electric Company, Schenectady, a Fellow of the Institute since 1912 and twice one of its Vice-Presidents, was the recipient of the honorary degree of Doctor of Science at the 133d Annual Commencement of Union College, Schenectady, June 1929. In conferring the degree, Doctor F. P. Day said of Mr. Robinson, "Lewis Taylor Robinson, inventor, engineer, musician, has for many years occupied a leading position in the world of electrical science. He has contributed materially to the progress of the art through many valuable inventions and papers before learned societies, giving unselfishly of time and energy as a member of many scientific national and international committees; a student in the truest sense of the word." Under his administration, the Laboratory has established and maintained a complete set of electrical standards for the Company beside his contributions of many important machines and devices, notable among which are the oscillograph, means for determining the magnetic properties of iron, mercury arc rectifier developments and recently a system of the motion pictures with sound. During 1919-1920 he was Chairman of the Institute's Standards Committee. He is also active on the Board of Trustees of the United Engineering Societies and was one of the Institutes representatives on the Joint Conference Committee which was responsible for the founding of the present American Engineering Council. He is a member of the U. S. National Committee of the International Electrotechnical Commission, of the Committee on Insulation of the National Research Council, the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, the N. E L. A., N. E. M. A., the Society of Engineers of Eastern New York, and the American Society of Motion Picture Engineers. He is also a Fellow of the American Physical Society. Many men now in the employ of the General Electric Company as well as in other companies served their apprenticeships with Dr. Robinson and it may be accurately said that his influence has abundantly permeated the electrical industry.

Obituary

Ralph L. Werden, of the Long Lines Engineering Department of the American Telephone and Telegraph Company, New York, and a Member of the Institute since 1918, died at Bogota, March 21, 1929, after a two-day illness of influenza and bronchial pneumonia. Mr. Werden was active in the work of the telephone line connecting New York and San Francisco; he was a trustee of the William F. Burk Lodge No. 230 and of the Bogota Masonic club. He also served on the general board of assessment commissioners.

Charles Francis Brush, inventor of the arc light, an outstanding scientist, humanitarian, philanthropist and one of the Institute's first Managers, 1884-1887, died at his home in Cleveland, Ohio, June 15, 1929 at the age of eighty, complications from bronchitis which developed into pneumonia causing his death.

Mr. Brush was born at Euclid, Ohio, March 17, 1849, both of his parents coming from old American families. His grammar and high school education was obtained in the public schools of Cleveland from which he was graduated at an early age. While still at school, he became intently interested in electrical apparatus and, in true boy fashion, experimented with his own construction of static machines, induction coils, and small motors; his graduating essay, in fact, was on the dynamo and arc light, based upon the Wilde experiments in London. In 1869 he was graduated in mining engineering from the University of Michigan, returning for a postgraduate course which won for him his M. S. degree, followed by a Ph. D. from the Western Reserve University. This latter university also conferred upon him an honorary degree of LL. D., as did also the Kenyon College in 1903.

It was in 1860 that the Italian, Paccinotti, made a great discovery in electricity, but it was destined to remain buried in the archives of Italian libraries until a young Belgian by the name of Gramme reinvented the dynamo electric machine.

Doctor Brush, then a young man just out of college, was one of the first to realize the value of this "nucleus" and to undertake further the history of its evolution and application with variation and improvement. By 1876 he had designed a dynamo—constructed under his own supervision—a pioneer machine to be exhibited at the Paris Exposition in the United States Historical Exhibit. In 1877 he introduced the compound field winding for constant potentials now so generally applied to electric lighting; its first use was in connection with plating machines. At the Charitable Mechanics' Fair in Boston, (1878), an exhibit of greatest historic and scientific interest, was displayed the earliest form of what afterward became the world-famous Brush arc light machine. His, too, was the great invention of the differential arc lamp, the construction and operation of which included the principle making it possible to operate lamps in series instead of in parallel. Another apparatus of great significance,—the automatic cut-out, permitting each lamp to cut itself out of circuit should trouble arise or the carbon burn out was of his development. This was looked upon as one of the greatest inventions of the era—a fact conceded by even Doctor Brush's contemporaries in the same field of development.

From that time on it was a rapidly growing industry. Copper plating of carbon electrodes was also introduced by Doctor Brush and yielded large royalties. In 1881 the Brush Electric Company was incorporated and capitalized at $3,000,000. Approximately ten years later when the General Electric Company was formed, it absorbed this company and the works were removed from Cleveland to Schenectady, but in the meantime, through the formation of other corporations, the Brush apparatus and system were being introduced. The storage battery problem received considerable attention from Doctor Brush, and as a result of his effort, great improvement was accomplished in the manufacture of lead plates. He too devised the ingenious system of charging storage batteries from an arc light system and the subsequent subdivision of light, demonstrating that it was possible to run incandescent lights on an arc light circuit.

In 1881 at the International Electrical Exposition in Paris there was exhibited by the English Brush Company as one of the most interesting features, a certain Brush apparatus. It was in this year too, that Doctor Brush was decorated by the French Government as Chevalier of the Legion of Honor; in 1889, the American Academy of Arts and Sciences awarded to him the Rumford medal, bestowed by both the Royal Society and the American Academy of Arts and Science, "for the most important discovery or useful improvement on heat and light." Doctor Brush is a corporator of the Case School of Applied Science, trustee of the Western Reserve University, Fellow of the American Academy of Arts and Sciences; member of the Physical Society, the American Philosophical Society; Fellow of the American Association for the Advancement of Science; Life Member of the British Association, Ohio State Board of Commerce, Cleveland Chamber of Commerce (of which he was also President 1909-10); The American Society of Mechanical Engineers; members of the Archeological Institute of America, the American History Association, the National Electric Light Association, the Franklin Institute, the American Chemical Society, the Royal Society of Arts; Fellow of the American Geographic Society and the N. British Academy of Arts. He was a Charter Member of the Institute and in 1913 received the Edison Medal award.

A. I. E. E. Section Activities

NEW YORK SECTION

Second Power Group Meeting. On the evening of Tuesday, May 28th, the Power Group of the New York Section held its second meeting. Through the courtesy of the New York Edison Company, the auditorium of the Consolidated Gas Building was made available, and the meeting called to order by Chairman George Sutherland at 7:45 p. m. A motion picture on the "Construction of the Conowingo Hydroelectric Development" was shown followed by the two papers: *The Economical Division of Generating Means*, by James D. Winans and F. W. Gay of the Public Service Production Co., and *Experience with the Rocky River Hydroelectric Development*, by E. J. Amberg of the Connecticut Light and Power Co. The first paper discussed from an economic standpoint the use of artificial water power (pump storage) and gasoline engines as a peak-load installation. The second paper was a discription of the only large pumped storage reservoir in this country, with operating experiences. General discussion followed. Attendance was about 125.

ANNUAL STUDENT PROGRAM OF PORTLAND SECTION

The annual joint meeting of the Portland Section and the Oregon State College Branch was held at the College on May 25, 1929, with an attendance of 170. The following program was presented by students:

The Neon Stroboscope, Artro Swingle and V. E. Kerley.

The Photoelectric Cell and Its Application to the Measurement of Illumination, R. W. Mize and Zed Atlee.

Characteristics of Bakelite Dielectric at Radio Frequencies, S. C. Bates and Fred M. Burelback.

Static Electricity in the Printing Industry, R. F. Williams.

Short-Time Fusion Characteristics of Copper Conductors, S. O. Rice.

The names of the officers of the Section for 1929-30 were announced as follows: Chairman, H. H. Cake, Pacific States Electric Co.; Secretary-Treasurer, A. H. Kreul, Portland Electric Power Co.; Executive Committee, L. W. Going, Chief, City Inspection Bureau, R. J. Davidson, Pacific Power & Light Co.

COMPETITION HELD BY SEATTLE SECTION

At a meeting held on May 21, 1929, the Seattle Section offered a cash prize of $25.00 for the best paper presented by one of its members who had never presented a paper at a Section meeting. The program was as follows:

Radio Interference from Suspension Insulators, E. L. White, Communication Engineer, Puget Sound Power and Light Co.

Kilovolt-Ampere-Hour Meters, Prof. G. R. Shuck, University of Washington.

Balanced and Directional Ground Relay Protection on Parallel Lines, T. T. Smith, Puget Sound Power and Light Co.

Operation of a Specific Interconnection, A. W. Mathis, Chief Load Dispatcher, Puget Sound Power and Light Co.

The prize was awarded to Professor G. R. Shuck. All the papers were considered of high quality.

Reports of several Section committees were presented, and the following officers were elected to take office August 1, 1929: Chairman, Dr. L. N. Robinson; Secretary-Treasurer, Prof. George S. Smith. The attendance was 82.

PAST SECTION MEETINGS

Akron

Joint meeting with Municipal University of Akron Branch. (Complete report on pp. 492-3 of June JOURNAL.) April 25.

Demonstration at the High-Voltage Laboratory of the Ohio Insulator Company, Barberton. Buffet luncheon was served by the Company and a brief talk was given by A. O. Austin, Chief Engr. May 10. Attendance 420.

Boston

Dinner meeting. The following officers were elected for next year: Chairman, W. H. Colburn; Vice-Chairman, J. P. Kobrock; Secretary-Treasurer, G. J. Crowdes; Members of Executive Committee: C. A. Corney, E. W. Dillard, R. W. Adams; Representative to The Affiliated Technical Societies of Boston, J. W. Kidder. Entertainment with C. C. Pierce as toastmaster. May 16. Attendance 200.

Cincinnati

Student program. (See report in Student Activities dept.) May 16. Attendance 35.

Cleveland

Talk by R. F. Schuchardt, President, A. I. E. E., on *Winning the World*, in which he urged engineers to cooperate with the city on great civic projects. Prof. H. B. Dates, Counselor, Case School of Applied Science Branch, spoke on the cooperation of the Student Branches with the Sections. Committee reports. The following officers were elected for next year: Chairman, Prof. T. D. Owens; Secretary-Treasurer, Wm. H. LaMond; Chairman, Meetings and Papers Committee, F. W. Braund; Members of Executive Committee, P. D. Manbeck, H. L. Martien, and F. R. Winders. Dinner preceded the meeting. May 23. Attendance 101.

Columbus

Joint meeting with Ohio State University Branch. (Report on p. 492, June Journal.) May 3. Attendance 40.

Dallas

The Laying of a New Armored Telephone Toll Cable, by G. A. Dyer, Plant Engr., Southwestern Bell Tel. Co. Motion pictures.

Construction Methods Used in Erecting a Transmission Line Across Desert Country, by J. B. Thomas, Chief Engr., Texas Power & Lt. Co. Illustrated. A report on the Dallas Regional Meeting was given. Result of recent election of officers to take office August 1 reported as follows: Chairman, J. B. Thomas; Secretary, A. Chetham-Strode; Chairman, Meetings and Papers Committee, D. H. Levy; Chairman, Entertainment Committee, C. G. Matthews; Chairman, Membership Committee, F. A. Cooper. May 22. Attendance 54.

Denver

Ladies' Party. Program in charge of Mrs. W. H. Bullock. Dinner, musical entertainment, and card party. May 16. Attendance 60.

Annual Meeting, held at University of Colorado. Address by F. W. Bradley, President, A. I. M. E. The Secretary presented the annual report. The following officers were elected for the year commencing August 1, 1929: Chairman, W. H. Bullock; Vice-Chairman, R. B. Bonney; Secretary-Treasurer, N. R. Love. May 23. Attendance 700.

Fort Wayne

Sixth Annual Banquet and Ladies' Night.

Astronomy, by Prof. Gingery, Principal, George Washington High School, Indianapolis. A report on the activities of the Section was given by the Secretary-Treasurer. Prof. W. T. Ryan, Vice-President, Great Lakes District, A. I. E. E gave a brief talk. The names of officers chosen in the recent election to take office August 1 were announced as follows: Chairman, F. W. Merrill; Vice-Chairman, J. F. Eitman; Secretary-Treasurer, E. J. Schaefer; Assistant Secretary-Treasurer, F. W. Winje; Executive Committee, A. L. Hadley, M. J. Payton. May 16. Attendance 58.

Houston

Automatic Traffic Control, by H. B. Cammack, Houston Electric Co. Officers of the Section elected for next year: Chairman, L. K. Del Homme; Secretary-Treasurer, C. D. Farman. Dinner meeting. May 22. Attendance 32.

Indianapolis-Lafayette

Talking Movies, a Development of the Telephone, by P. L. Thompson, Western Elec. Co., with demonstration of equipment and several reels of talking pictures. The Chairman reported results of election of officers for coming year. Joint meeting with A. S. M. E. Section. May 28. Attendance 275.

Kansas City

132,000-Volt Cables, by W. S. Clark, Engineer-in-Charge, Cable Dept., General Elec. Co. Slides. Several members reported on the Dallas Regional Meeting. Election of officers for next year as follows: Chairman, A. B. Covey; Secretary-Treasurer, J. S. Palmer. May 20. Attendance 63.

Los Angeles

Science and Research in Telephone Development, by S. P. Grace, Ass't. Vice-President, Bell Telephone Laboratories, Inc. The Executive Committee entertained Mr. Grace at dinner. Chairman Caldwell announced the results of the recent election as follows: Chairman, N. B. Hinson, Secretary, H. W. Hitchcock; Assistant Secretary, P. S. Biegler; Executive Committee, F. E. Dellinger, C. E. Johnson, A. P. Hill and F. W. Maxstadt. May 14. Attendance 2250.

Louisville

The Engineer and the Modern Community, by J. P. Barnes, President, Louisville Railway Co. Committee reports. Election of officers for next year: Chairman, H. W. Wischmeyer; Secretary-Treasurer, P. P. Ash; Executive Committee, R. E. Tafel, T. B. Carter, S. T. Fife, and E. D. Wood. May 31. Attendance 24.

Lynn

The Experiences of a Newspaper Photographer, by A. H. Blackington. Illustrated lecture. Ladies' Night. May 7. Attendance 350.

Lecture by Dr. G. H. Bigelow, Massachusetts Commissioner of Public Health. Dr. Williams, U. S. Public Health Commission spoke on mosquitoes and methods of destroying them. The following officers were elected for next year: Chairman, I. F. Kinnard; Vice-Chairman, A. L. Ellis; Secretary-Treasurer, H. K. Nock; Assistant Secretary, W. K. Dickinson; Chairman, Membership Committee, L. E. Hildebrand; Chairman, Entertainment Committee, W. C. Harris; Chairman, Local Convention Committee, Dr. S. A. Moss; Chairman, Trip Committee, M. S. Wilson; Chairman, Publicity Committee, R. D. Amsden; Local Member, Executive Committee, H. A. Rising. Refreshments served. May 16. Attendance 50.

Madison

Slides describing "Kinematographic Studies in Aerodynamics." Baron Shiba high-speed motion pictures, and film "The Flight of Birds." The retiring Chairman, Prof. L. J. Peter urged that a few of the programs next year be made up from local talent together with round table discussions of engineering problems. Several excellent suggestions were given by the Section members for future meetings. Committee reports presented. May 22. Attendance 100.

Mexico

Lecture by A. F. Martinez, Asst. Engr., Distribution Dept., Mexican Lt. & Pr. Co., on methods of calculation for the proper location of trolley wire in curves and suggestions for the procedure to be followed during installation. April 16. Attendance 16.

Lecture by B. M. Antipovitch, Asst. Engr., Elec'l Dept., Mexican Lt. & Pr. Co., on operating characteristics of radio apparatus. May 14. Attendance 15.

Milwaukee

Some Examples of the Use of Electricity for Measuring Non-Electrical Quantities, by Arthur Simon, Cutler-Hammer Mfg. Co.;

Electrical Measuring and Control for Economical Production of Gas, by C. S. Pinkerton, and

Automatic Mixing of Gases, by E. Schmidt. April 3. Attendance 70.

Minnesota

Meeting held to stimulate interest in the World Engineering Congress to be held in Tokio, Japan, in November. Motion picture film on important engineering projects in Japan, with introductory talk by Max Toltz. A travelogue showing a trip through the Orient was presented by Victor Bloom, a world traveler with the American Express Company, with lantern slides. Joint meeting with Sections of A. S. C. E, A. S. M. E., Minneapolis Engineers Club, St. Paul Engineers Society and A. I. E. E. Branch. May 6. Attendance 60.

Niagara Frontier

Charles R. Huntley Station: Turbo-Generators, Auxiliaries, and Controls, by E. P. Harder, Engg. Dept., Buffalo General Electric Co., and

Powdered Fuel Boilers, by H. M. Cushing, Chief Engr., Buffalo General Electric Co. Dinner preceded the meeting. April 19. Attendance 100.

Oklahoma

Joint meeting with Student Branches (See report in Student Activities dept.). May 24. Attendance 35.

Philadelphia

Electricity and Chemistry, Teammates in Progress, by Dr. H. E. Howe, Editor, Industrial & Engg. Chemistry. Dinner preceded the meeting. May 13. Attendance 60.

Pittsburgh

Miracles of Science, by H. C. White, Edison Lamp Works, General Electric Co. Election of officers for next year. Annual dinner meeting. Ladies were invited. May 21. Attendance 700.

Portland

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. May 28. Attendance 2400.

St. Louis

Meeting Long Distance Telephone Problems, by John Casey, Transmission Engr., Southwestern Bell Tel. Co. (Prepared by H. R. Fritz, Transmission and Protection Engr. of the same company). Attendance prizes awarded to J. N. Embree, J. B. Baltzer, Ned Crider, L. O. Campbell, G. H. Quermann, C. P. Potter, and H. P. Strieder. May 15. Attendance 43.

Saskatchewan

Joint dinner meeting with Regina District Amateur Radio Club. Radio Communication in the North West Territory, by Capt. H. A. Young, R. C. C. S. March 8. Attendance 30.

Joint dinner meeting with Regina District Amateur Radio Club. *The Nature of Electrical Conduction through Metals*, by Dr. Thomas Alty, Professor of Physics, Saskatchewan University. April 12. Attendance 36.

Seattle

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Tel. Laboratories, Inc. June 4. Attendance 2040.

Sharon

The Latest Developments in Electrical Engineering, by W. D. Shirk, Westinghouse Electric & Mfg. Co.;

The Aston Process for Making Wrought Iron, by Dr. Jas. Aston, and

The Latest Developments in Central Stations, by C. S. McCalla. Joint dinner meeting, Youngstown, with Youngstown Branch, Iron & Steel Electrical Engrs. May 11. Attendance 150.

Communism, by Capt. J. R. O'Brien, under the auspices of the Constitutional Educational League of America. Prof. J. L. Beaver, Vice-President, District No. 2, gave a brief talk, in addition to a short talk by J. S. Hebrew, Westinghouse Elec. & Mfg. Co. Annual Banquet, H. L. Cole, toastmaster. June 4. Attendance 197.

Springfield

Illuminating Engineering with Special Reference to Spectacular Effects, by W. D. Ryan, Director of the Illuminating Laboratory, General Electric Co. Slides. Annual Ladies' Night. April 22. Attendance 250.

Discussion of proposed changes in Institute publications as outlined in circular letter of W. S. Gorsuch, Chairman, Publication Committee. May 20. Attendance 25.

Toronto

The Value of a Museum to Industry and the Home, by Dr. E. T. Currelly, Curator, Royal Ontario Museum. Chairman E. M. Wood, reported upon the past year's activities. Reports were given by the Secretary and by the Chairman of the Meetings and Papers Committee of the Section. A. B. Cooper, Vice-President, District No. 10, presented the Regional Prize for Initial Paper to H. R. Sills, Canadian General Electric Co. Chairman Wood presented the Toronto Section prize of $20.00 to R. E. Jones for the best paper given before the Toronto Section. Following officers elected for next year: Chairman, F. F. Ambuhl; Secretary, W. F. Sutherland; Executive Committee, A. D. Bradt, J. Chipperfield, T. W. Eadie, G. D. Floyd, D. A. MacKenzie and Jos. Showalter. May 10. Attendance 62.

Urbana

Election of officers for next year: Chairman, M. A. Faucett; Secretary, C. E. Skroder. May 21. Attendance 20.

Utah

Dance. May 24. Attendance 100.

Vancouver

Reports of officers and committees. The Regional First Prize for District No. 10 for 1928 was presented to H. M. Lloyd for his paper entitled "Railway Motors." Following officers elected for next year: Chairman, J. Teasdale, British Columbia Electric Railway Co.; Executive Committee, C. W. Colvin, G. R. Wright, and H. Vickers. General discussion of ways and means of increasing Section's attractiveness and value to members. June 4. Attendance 31.

Washington

Mercury Arc Rectifiers, by F. A. Faron, Railway Dept., General Electric Co. Dinner in honor of the speaker preceded the meeting. Election of officers to take office August 1. Light refreshments. May 14. Attendance 120.

Worcester

Inspection of the electrically operated billet mill and continuous rod mill at the South Works of the American Steel & Wire Co. Election of officers for the year 1929-30. Business meeting was followed by motion pictures of the manufacture of paper insulated power cable. June 5. Attendance 32.

A. I. E. E. Student Activities

STUDENT PROGRAM IN CINCINNATI

At a joint meeting of the Cincinnati Section and the University of Cincinnati Branch held at the University on May 16, 1929, the principal parts of the program were supplied by graduate students as indicated below:

J. E. Middleton, atomic hydrogen welding; C. D. Clark, subscriber telephone circuits; Wm. Kutcher, electrolytic condensers; R. P. Glover, radio broadcast receivers; J. J. O'Callaghan, commercial frequency meters for radio work; C. D. Coy, electromagnetic sound systems; R. E. Colado, d-c. street railway feeder protection; W. P. Fegley, bi-metallic thermostats.

The attendance was 35.

JOINT MEETING OF OKLAHOMA SECTION AND NEIGHBORING BRANCHES

The Oklahoma Section and the University of Oklahoma and Oklahoma A. & M. College Branches held their annual joint meeting at Stillwater on May 24, 1929. The following program was presented by students and professors:

A Survey of Oil Field Electrification in Oklahoma, Prof. R. E. Willey, Oklahoma A. & M. College.

The Condenser Type Single-Phase Motor, Prof. B. A. Fisher, Oklahoma A. & M. College.

Design of Direct-Current Calculating Table, Richard Mason and Byron J. Cook, University of Oklahoma.

The Relation between the Gain in Egg Production by Artificial Methods and Per cent Sunshine, G. T. Isbell, Oklahoma A. & M. College.

Thermal Characteristics of Underground Cable Ducts, Ralph W. Coursey, University of Oklahoma.

Thermal Characteristics of Underground Transformer Vaults, Roy L. Jones, University of Oklahoma.

Interference Elimination by Use of Vacuum Tube Bridge, J. E. Peek, Oklahoma A. & M. College.

Radio Flying Aids with Special Reference to the Absolute Altimeter, E. P. Shultz and Wm. A. Woods, University of Oklahoma.

Some Examples in the Determination of Empirical Equations, Kenton D. McMahan, Oklahoma A. & M. College.

Piezo electric Crystal-Controlled Oscillators, LeRoy Moffett, Jr., University of Oklahoma.

A first prize of $15.00 and a second prize of $10.00 were awarded to K. D. McMahan and Roy L. Jones, respectively.

After the completion of the program, a luncheon was held in the College cafeteria, and in the afternoon the faculty members escorted the visitors through the buildings. The attendance was 35.

STUDENT BRANCH ORGANIZED AT NORTH DAKOTA

At the meeting of the Board of Directors held on May 22, 1929, authority was granted for the formation of a Student Branch of the Institute at the North Dakota Agricultural College. This Branch has been organized and the following officers were elected: Chairman, J. C. Langaunet; Vice-Chairman, Lewis Nelson; Secretary-Treasurer, R. W. Scott.

BRANCH MEETINGS

University of Arizona

Motion picture, "Electrical Measuring Instruments." April 10. Attendance 16.

Storage Batteries, by Carl Gieringer, student;

Lightning Phenomena, by Frank Henderson, student, and

Estimating and Drafting for Electrical Work with the Southern Pacific Railroad, by Barney Shehane, student. April 17. Attendance 18.

Television, by O. K. Mangum, student, and

Electric Elevators, by Fred Denny, student. April 24. Attendance 20.

Remote Control of Torpedoes, by George Walton, student, and

Hydrogen Cooling of Electrical Machinery, by Roy Goar, student. May 1. Attendance 14.

Tidal Power, by C. A. Macris, student, and

Charging Equipment for Electric Automobiles, by John McBride, student. May 8. Attendance 13.

Voltage Standardization, by Harold Soliday, student. Following officers elected to take office immediately: President, Barney Shehane; Vice-President, Roy Goar; Treasurer, G. W. Walton; Secretary, F. F. Denny. May 15. Attendance 17.

Niagara Falls, by Wm. Tremaine, student, and

Tucson Gas and Electric Company, by Max Pooler, President, Tucson Public Utilities Corp. Dinner preceded the meeting May 22. Attendance 24.

Turbine Electric Propulsion of Ships, by O. K. Mangum, student, and

Public Utilities, by Stanley McKinley, student. May 29. Attendance 16.

University of Arkansas

T. E. Peter and H. C. Claybaugh gave a report on the Regional Meeting in Dallas. D. J. Morrison elected Chairman for next year. May 17. Attendance 12.

Armour Institute of Technology

Illumination and Engineering, by Mr. Faulks, Curtis Lighting Co. April 8. Attendance 103.

Development and Manufacture of Loudspeakers, by Mr. Cling, Western Electric Co. April 22. Attendance 119.

Business Meeting. Following officers were elected for next year: Chairman, Jack Dollenmaier; Vice-Chairman, J. G. Papantony; Secretary, Stephen Janiszewski; Treasurer, Carl Rudelius. May 6. Attendance 65.

California Institute of Technology

Business Meeting. Election of officers for next year. May 16. Attendance 25.

Clemson Agricultural College

Chemistry and Electricity, by Cadet G. W. Sackman, and

Current Events, by Cadet J. H. Graves. April 11. Attendance 20.

Colorado Agricultural College

Business Meeting. Following officers elected for next year: Chairman, G. E. Branch; Vice-Chairman, J. P. Griffin. May 13. Attendance 10.

Annual spring inspection trip with A. S. M. E. Branch to Colorado Springs, Pueblo, and Denver. May 24. Attendance 36.

University of Denver

"Open House" Electrical Show. *The Accuracy of Watthour Meters at Various Power Factors*, by Joseph Cohen and J. N. Petrie; *Variation of the Pole Strength of a Permanent Magnet As Dependent upon Its Weight*, by F. A. St. John; *Visible Distribution of a Radio Wave along a Wire*, by Dale S. Cooper, and a *Demonstration of the Grid Glow Tube*, by J. L. Wright. Mr. Cato illustrated the detail of another practical "perpetual motion" machine. After the program the Physics Laboratories were inspected and refreshments were were served. May 2. Attendance 82.

University of Detroit

Practical Views on Arc Welding, by A. Robinson, Detroit Sales Mgr., The Lincoln Electric Co. Motion pictures—"From Mine to Consumer" and "Sheet Copper." May 28. Attendance 60.

Georgia School of Technology

Lightning and Its Relation to Transmission Lines, by C. E. Bennett, Georgia Power Co. May 15. Attendance 49.

Business Meeting. Following officers elected for next year: Chairman, L. B. Mann; Vice-Chairman, H. C. Vickery. May 21. Attendance 21.

Kansas State Agricultural College

A Graphical Solution of Networks, by E. G. Downie. May 2. Attendance 137.

University of Kansas

Brief talks by about ten seniors on the work they are to do after graduation. Refreshments served. May 23. Attendance 51.

Annual picnic of the electrical seniors. May 29. Attendance 25.

University of Kentucky

Business Meeting. Election of Officers. May 15. Attendance 51.

University of Louisville

Patents in Radio, by Mr. Kraprak. May 27. Attendance 24.

Marquette University

Business Meeting. Following officers elected: President, H. W. Haase; Vice-President, Amos Petit; Secretary, G. C. Reichert; Treasurer, George Maurer. April 18. Attendance 27.

Power Generation for Private Uses, by Prof. Frommelt, Head, Mechanical Engineering Dept. Prof. J. F. H. Douglas, Counselor, urged the students to prepare and present more papers. May 9. Attendance 22.

Michigan State College

Electric Arc Welding, by Mr. Willert. Illustrated lecture.

Electric Welding from a Construction Engineer's Viewpoint, by Mr. Henson, Civil Engg. Dept. Election of officers. May 8. Attendance 36.

School of Engineering of Milwaukee

Substation Operation, by F. W. Sulensky, Assistant Chief Operator, Milwaukee Elec. Railway & Lt. Co. May 14. Attendance 43.

University of Minnesota

Demonstration of Televox, by L. J. McCoy, Westinghouse Elec. & Mfg. Co. April 20. Attendance 600.

G. N. Anderson, Transmission Engr., Northwestern Bell Telephone Co., gave a lecture and demonstration on the effects of suppressing lower and higher frequencies in the reproduction of music and voice over transmission lines and the effects of trouble in telephone circuits. May 1. Attendance 155.

Missouri School of Mines & Metallurgy

Motion pictures, "Power Applications in the Bituminous Industry," "Panama Canal," "The Induction Voltage Regulator," and "Manufacture of Steel Ties." April 23. Attendance 28.

Montana State College

Election of officers: President, E. B. Wilson; Vice-President, E. G. Rudberg; Secretary, Otto Van Horn; Treasurer, Robert Jones. May 23. Attendance 71.

University of Nebraska

Regulation, by F. C. Curtis, Chairman, State Railway Commission. Joint meeting with A. S. M. E. Branch. Other engineering student societies invited. May 14. Attendance 40.

The Superheterodyne, Theory and Operation, by G. W. Cowley, student. Talks were given by the followng graduating seniors: Philip Fink, E. B. Hiltner, M. E. Scoville, Lester Shoemaker, and Malcolm Shoemaker. Mr. Bickley, Northwestern Bell Telephone Co., gave a short talk. Motion picture, "BTA. Alternating-Current Motor." Refreshments served. May 22. Attendance 29.

University of New Hampshire

Insulation, by H. Smith, student and

Luminous Steam, by P. Morton, student. May 4. Attendance 26.

Permissible Storage Battery Mine Locomotives, by J. Theall, student, and

Shaft and Rotor Assembly, by J. Terry, student. May 25. Attendance 27.

Motion picture on the story of copper, from mine to user. June 1. Attendance 28.

North Carolina State College

Business Meeting. Committee Chairmen were appointed for next year. May 21. Attendance 15.

University of North Carolina

Election of officers for next year. May 16. Attendance 27.

University of North Dakota

Airport Lighting, by Arthur Miller, student. May 22. Attendance 14.

Northeastern University

Talk by Prof. W. H. Timbie, Massachusetts Institute of Technology. Election of officers. May 28. Attendance 63.

Ohio Northern University

The Relations of Law and Engenereing, by Dr. Small, Secretary of University. May 16. Attendance 24.

Ohio State University

Program was presented by the graduating students who reported upon their thesis work: *Altitude Measurements by Reflected Electromagnetic Waves*, by R. C. Newhouse; *Secrecy System for Carrier Current Telephony*, by E. R. Robinson; *Effect of Conductor Insulation upon the Critic Formation of Corona*, by Robert Spry; *Airport Illumination*, by G.W. Trout; *Effect of the Mixture of Light Waves upon the Speed of Vision*, by D. A. Warstler, and *Efficiency of High-Frequency Generators and Transmission Lines*, by J. D. Ryder. May 23. Attendance 40.

Oklahoma A. & M College

A brief report on the Regional Meeting at Dallas by E. L. Weathers, Chairman. Election of officers for next year. follows: Chairman, Hugh V. Anderson; Vice-Chairman, Wilbur E. Slemmer; Secretary-Treasurer, Early F. Neal. May 16. Attendance 18.

University of Oklahoma

A banquet was given by the Juniors in honor of the Graduating Electrical engineering students. Talks were given by the seniors. April 10. Attendance 44.

Smoker and general discussion pertaining to activities for next year. Election of officers for next year. May 20. Attendance 18.

Oregon State College

Joint meeting with Portland Section. (See report in Section Activities dept.). May 25.

Purdue University

Engineering and Patent Law, by A. M. Horn, Patent Attorney. Joint meeting with A. S. M. E. Branch. May 1. Attendance 45.

Rutgers University

Difficulties Students May Encounter with Motors, by Mr. Evans, Century Electric Co. April 30. Attendance 19.

A Trip to the General Electric Company's Plant, by W. Dalton, '29, and

The Organization of the Westinghouse Electric Plant, by Mr. Walton, '29. Business session. May 7. Attendance 20.

Air Blast Transformers, by A. S. Beams, '30, and

Long Distance Telephone Lines, by R. K. Shepard, '30. May 14. Attendance 18.

Election of officers. May 16. Attendance 21.

University of South Dakota

The Spectroheliscope, Spectroheliograph and Spectroscope, by Evire Lovejoy, student. May 21. Attendance 10.

Various Theories Formulated in the Last One Hundred Years Concerning the Structure of Matter, by Philip Miller, student. May 28. Attendance 12.

Stanford University

Smoker. Talks by Dr. C. D. Marx, Professor Emeritus of Civil Engg.; T. J. Hoover, Dean of the School of Engg. and Dr. Harris J. Ryan, Professor of Elec. Engg. The following officers were elected for next year: Chairman, D. A. Murray; Vice-Chairman, G. S. Kimball; Secretary-Treasurer, H. E. Hill; Member of Executive Committee, J. S. Low. Refreshments served. May 9. Attendance 47.

Operation of the Dial Telephone, by Mr. Becker, Palo Alto Office, The Pacific Tel. & Tel. Co. D. A. Murray, Chairman-elect, gave a brief talk and read President Schuchardt's message in the May issue of the JOURNAL. May 23. Attendance 20.

Inspection trip to Radio Station KPO, San Francisco. May 25. Attendance 10.

University of Tennessee

Election of officers for next year. May 15. Attendance 26.

University of Texas

The Future of an Engineer, by Prof. J. A. Correll, Counselor. Plans for next year were discussed and Prof. Correll offered several suggestions. Election of officers. May 16. Attendance 10.

University of Utah

Election of officers. May 7. Attendance 12.

University of Vermont

Business meeting. Officers for next year were elected as follows, and take office immediately: Chairman, F. E. Beckley; Vice-Chairman, R. F. Bigwood; Secretary-Treasurer, A. E. Merrill. May 8. Attendance 14.

Virginia Military Institute

Election of officers for next month. June 7. Attendance 32.

Virginia Polytechnic Institute

Labon Backer was elected Chairman to take office in September. May 22. Attendance 20.

University of Virginia

Prof. W. S. Rodman, Counselor, gave a brief talk concerning Branch work for next year. Election of officers for next year. May 20. Attendance 16.

Washington State College

Committee reports. April 17. Attendance 27.

Committee reports. May 8. Attendance 18.

Amendments to Branch By-laws adopted. Election of officers for next year. May 29. Attendance 27.

Washington University

Radio Broadcasting, by Thomas P. Convey, Station KWK, St. Louis. Smoker for students of the Branch, faculty members, and alumni. Engineers' Club of St. Louis. May 2. Attendance 80.

Officers elected for next year. May 16. Attendance 30.

University of Washington

The U. S. Army Ordinance, by Capt. L. P. Crim, U. S. Army Ordinance Dept. Slides. Election of officers for next year. Karl E. Hammer, Chairman for next year, gave a brief talk and presided. May 10. Attendance 14.

Business meeting. Voted to appropriate $25.00 for a research prize plaque. May 17. Attendance 20.

The Salmon Canning Industry in Alaska, by H. C. Hurlbut, student. May 24. Attendance 7.

University of Wisconsin

Recent Research Developments of the Westinghouse Electric & Mfg. Company, by C. E. Skinner, Asst. Director of Engineering of that company. Joint meeting with Madison Section. April 16. Attendance 12.

Worcester Polytechnic Institute

Television, by L. F. Cleveland, '29. R. W. Puddington gave a report on the Student Convention at Troy. Refreshments. May 21. Attendance 26.

Yale University

Science and Research in Telephone Development, by S. P. Grace, Asst. Vice-President, Bell Telephone Laboratories, Inc. Joint meeting with Connecticut Section. April 23. Attendance 2500.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, MAY 31, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

DIE ABWÄRMETECHNIK, bd. 3; Sondergebiete der Abwärmetechnik.

By Hans Balcke. Mün. u. Ber., R. Oldenbourg, 1928. 242 pp., illus., diagrs., 9 x 6 in., cloth. 13,50 r. m.

The third volume of Dr. Balcke's treatise on waste-heat engineering is devoted to methods of using waste heat in several important fields. These include its use for obtaining distilled feedwater for boilers, for concentrating liquids, for drying, for humidifying workrooms, and for refrigerating. Other matters discussed are its utilization on freight steamships, the utilization of excess electric energy, and modern measuring instruments and methods.

The three volumes form a very complete exposition of waste-heat engineering.

BEITRAG ZUR KLARUNG DER FRAGE, WIE DIE ASCHE NACH MENGE UND ART IM KOHLENSTAUB ENTHALTEN IST, UND WELCHE WEGE GEGEBEN SIND, SIE TROCKENMECHANISCH ZU BESEITIGEN.

By H. Schwartzkopff. (Fünfzehnte Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates). Berlin, V. D. I. Verag, 1929. 24 pp., illus., diagrs., tables, 12 x 9 in., paper. 2,50 r. m.

The report of an investigation of the practicability of removing the ash from powdered coal by dry methods. The distribution of ash in powdered coal of various degrees of fineness was determined, as well as its character. Electrostatic, electromagnetic, and pneumatic methods of separation were examined. The conclusion was reached that dry methods of removing ash are not very efficient at present and would not be economical.

BUILDING ESTIMATORS' DATA BOOK.

By Charles F. Dingman. N. Y., McGraw-Hill Book Co., 1929. 159 pp., illus., tables, 7 x 4 in., fabrikoid. $2.50.

Tables are given for all the ordinary operations of building, with directions for their use. Carefully selected mathematical tables, formulas and constants are also included. The data are arranged for ready use with calculating machines and show in most cases the number of labor hours required for a given quantity of construction.

CONDUCTION OF ELECTRICITY THROUGH GASES.

By K. G. Emeléus. Lond., Methuen & Co., 1929. 94 pp., diagrs., tables, 7 x 4 in., cloth. 2/6.

This little monograph is designed to give an up-to-date outline of the main phenomena that can be studied quantitatively in connection with the passage of electricity through gases at low temperatures. It will be useful to those not in contact with recent work. A list of references is given for those who wish to pursue the subject further.

DIE DAUERFESTIGKEIT DER WERKSTOFFE UND DER KONSTRUKTIONSELEMENTE.

By Otto Graf. Berlin, Julius Springer, 1929. 131 pp., illus., diagrs., tables, 10 x 7 in., paper. 14.-r. m.

A review of our knowledge of the permanent strength of materials when subjected to repeated and long continued stresses. Brings together in convenient form the available results of tests by the author and other engineers. The materials discussed include steel, cast iron, cast steel, copper, nickel, aluminum, magnesium and their alloys, stone, reinforced concrete, wood, and glass.

EARTH FLEXURES; Their Geology and their representation and analysis in geological section with special reference to the problem of Oil finding.

By H. G. Busk. Cambridge. Eng. University Press, 1929. N. Y., Macmillan Co. 106 pp., illus., diagrs., maps, 10 x 7 in., cloth. $4.00.

Modern development of the petroleum industry has created a demand for more exactitude and detail in geological methods of survey and section drawing. Mr. Busk here deals with one of the problems involved, that of section drawing.

His book aims to show how the information supplied from the geological map may be best applied, how geometric methods may be used for section drawing of folds, and what are the pitfalls that lie in the way of exactitude. In addition he illustrates his methods by an account of their application in Burmah, Persia, and the Sinai peninsula.

ECONOMICS OF COAL MINING.

By Robert W. Dron. Lond., Edward Arnold; [N. Y., Longmans, Green & Co.], 1928. 168 pp., diagrs., tables, 9 x 6 in., cloth. $4.20.

A concise review of the practical economic problems which confront those engaged in coal mining in Great Britain. The subjects discussed include mineral leases, the valuation of minerals and collieries, the development of new collieries, power production, capital expenditure, organization of the industry,

and coal cleaning. The author is vice-president of the Institution of Mining Engineers.

Electric Wiring, Theory, and Practice.

By W. S. Ibbetson. 3rd edition. Lond., E. & F. N. Spon; N. Y., Spon & Chamberlain, 1929. 424 pp., illus., diagrs., 8 x 5 in., cloth. 7s 6d.

A clear description of the subject, giving much practical detail and covering all the matter needed in ordinary work. A good guide to current British practise.

Engineering for Masonry Dams.

By William P. Creager. 2d edition. N. Y., John Wiley & Sons, 1929. 294 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.

The topics here discussed include the investigation of sites, the choice of type of dam, the forces acting on dams, the design of various types, the preparation of foundations, flood flows, details and accessories, and head-water control. The methods of design described and the assumptions recommended conform to conservative present practise.

Die Grundbautechnik und Ihre Maschinellen Hilfsmitgel.

By G. Hetzell and O. Wundram. Berlin, Julius Springer, 1929. 399 pp., illus., diagrs., 10 x 7 in., bound. 35.-r. m.

A comprehensive survey of modern practise in foundation engineering and of machinery for building foundations. The engineering principles involved—kinds of soil, materials, earth pressures and bearing capacities—are presented, and the various methods of constructing foundations are described. About one-half of the book is devoted to contractors' machinery—cranes, conveyors, pumps, concrete mixers, pile-drivers, etc.

Grundlagen und Geräte Technischer Längenmessungen.

By G. Berndt. 2d edition. Berlin, Julius Springer, 1929. 374 pp., illus., diagrs., tables, 10 x 7 in., bound. 43,50 r. m.

This treatise, by the head of the Institute for Measurement and the Principles of Interchangeable Manufacturing at Dresden, surveys the scientific principles of measurement and the instruments for practical use. The evolution of the usual standards is described, and the methods by which shop and control standards of length are made and calibrated are discussed. Consideration is also given to the various types of gages and other measuring instruments that are used in industry, to their applications and exactness. Physiological errors in measurement and the reference of the meter to the wave-length of light are discussed in appendixes. The book contains a great amount of information on an important subject.

History of Mechanical Inventions.

By Abbott Payson Usher. N. Y., McGraw-Hill Book Co., 1929. 401 pp., illus., 9 x 6 in., cloth. $5.00.

This book is a systematic account of the development of the major mechanical inventions from their beginnings to the present time. Professor Usher's interest in the subject arises through its character as a basic element in economic history; as a result, he treats the subject in a broad way, with a minimum of technological detail, and with emphasis on matters of importance to society in general.

Introductory chapters discuss the place of technology in economic history and the process of mechanical invention. The early history of mechanical science and the mechanical equipment of antiquity are then described. Succeeding chapters trace the history of waterwheels and windmills, clocks and watches, printing, the textile industries, machine tools, and power production. A chapter is devoted to Leonard da Vinci. Excellent illustrations and a good bibliography are included.

Industrial Traffic Management.

By Leslie Aulls Bryan. Chic., A. W. Shaw Co., 1929. 392 pp., graphs, forms, 9 x 6 in., cloth. $4.00.

Aims to present the established economic principles of the subject in a form suited for a college text and for use as a reference work in practise. Discusses general principles, the details of organizing and administering industrial traffic, and the legal considerations involved.

Inorganic Chemistry for Colleges.

By William Foster. N. Y., D. Van Nostrand Co., 1929. 838 pp., illus., port., diagrs., tables, 9 x 6 in., cloth. $3.90.

Professor Foster's aim is to provide a textbook for college students who have studied the subject in the high school, and are thus prepared for a more advanced treatment of chemistry than beginning students. The book covers the usual ground, presenting the fundamental laws and theories, and the properties of the elements and their compounds, but the presentation is broader and more mature, as well as more thorough, than the usual college text.

International Critical Tables of Numerical Data, Physics, Chemistry, and Technology.

V. 4 & 5. N. Y., McGraw-Hill Book Co., 1928-1929. 2 v., 11 x 9 in., cloth. $12.00 each.

Two additional volumes of this great work will be welcomed by all scientific workers. Volume 4 contains phase-equilibrium data, osmotic pressures, and data upon surface tension, surface energy, and other properties of surfaces. Volume five has the numerical data of viscosity, specific heat, thermal conductivity, radiometry, photometry, and photography, and the properties of soaps and soap solutions. The data are based upon a critical study of all recorded observations and are indispensable to the investigator.

Jahrbuch der Deutschen Gesellschaft für Bauingenieurwesen, 1928.

Berlin, V. D. I. Verlag, 1929. 227 pp., illus., port., diagrs., tables, 8 x 6 in., paper. 10.-r. m.

The yearbook for 1928, like its predecessors, combines with the proceedings of the society considerable matter of use to civil engineers which is not easily found elsewhere. Papers are included on modern processes for purifying sewage, on the Eickhoff Brothers' machine works, and on signals for railways, waterways, highways, and airways. Lists are given of the German laboratories for testing materials of important engineering projects completed in Germany during 1927 and 1928, of new German engineering standards and of dissertations presented to German universities for the degree of Doctor of Engineering during 1926 to 1928. There is also a report on the tests of wind pressures on framed structures carried out at the Goettingen Aerodynamic Institute.

Journal, v. 2., pt. 1, January 1929, of the Royal Technical College, Glasgow. 155 pp., 10 x 7 in., paper. 10s 6d.

Among the papers of special interest to engineers are: tensile tests on rods and wires of the same iron, the magnetrostriction of various steels, the effect of annealing upon the solidus temperature of alloys, tempering changes in steels, the fuel-injection process in the air-injection oil-engine, the design of high-voltage condenser type insulator bushings, and the regional development planning of colonies.

Law for Engineers and Architects.

By Laurence P. Simpson and Essel R. Dillavou. St. Paul, West Publishing Co., 1929. 633 pp., 9 x 6 in., cloth. $4.50.

This textbook has been specially written to give the student of engineering or architecture a knowledge of the fundamental principles of law, illustrated by cases in which they are applied to those professions. The work is designed for the courses given at the University of Illinois.

The subjects treated include contracts, agency, workmen's compensation, mechanics' liens, property, regulation of public utilities, negotiable instruments, and sales. An appendix gives standard forms for building contracts, invitations to bidders, agreements between architect and owner, etc. The book will give the reader a knowledge of fundamental legal principles which will enable him to avoid many pitfalls and protect his interests.

Memoirs and Addresses of Two Decades.

By Dr. J. A. L. Waddell. Edited by Frank W. Skinner. Easton, Pa., Mack Printing Co., 1928. 1174 pp., illus., port., tables, 9 x 6 in., cloth. $5.00.

This volume supplements the collection of Dr. Waddell's professional writings prepared about 25 years ago by Mr. John Lyle Harrington. It contains seventy-five papers, together with a biographical sketch and brief summaries of the papers in the earlier volumes.

The papers now presented consist of addresses and contributions to periodicals during the last 22 years. These are grouped under 11 headings—the engineering profession, ethics of engineering, engineering literature, alloy bridge steels, economics, bridge construction, contracts, railroads, Chinese matters, and miscellaneous topics. The volume shows in a most interesting way the broad field of activity that Dr. Waddell has covered in his busy career, while his excellent style affords a useful model for every young engineer who wishes to write.

Mining Subsidence.

By Henry Briggs. Lond., Edward Arnold & Co., N. Y., Longmans, Green & Co., 1929. 215 pp., illus., tables, 9 x 6 in., cloth. $5.50.

Professor Briggs gives a thorough discussion of this very

important subject. The theories of subsidence are reviewed critically, the records of subsidences in Great Britain, America, and India are discussed, and the effects of bending and shearing of strata are investigated.

Nouvelles Etudes Sur La Chaleur.

By Ch. Roszak and M. Véron. Paris, Dunod, 1929. 765 pp., 10 x 6 in., paper. 208 fr.

This book, the work of two well-known French specialists in heat and refrigeration, is devoted to some questions that have heretofore been studied only superficially, as well as to certain new problems.

The opening chapter explains why the development of heating apparatus is still embryonic. The authors then set forth the relations between the production of heat and cold and the conditions of life on the earth. From this they proceed to a study of the different ways by which heat is propagated, by mixing, conduction, convection and radiation. The results obtained in this theoretical study are then applied critically to modern steam generators, and directions in which improvement still seems possible are pointed out.

The remaining chapters discuss problems not connected with heat transmission, but of interest to the same engineers. They include a comparison of American and French rules for boiler construction, a discussion of district heating, and an account of Berthelot's method of hydrogenation, the basis of many recent processes for the synthesis of petroleum.

Die Organisation der Wärmeüberwachung in Technischen Betrieben.

By Hans Balcke. Mün. u. Ber., R. Oldenbourg, 1929. 312 pp., illus., diagrs., tables, 9 x 6 in., cloth. 17,50 r. m.

The chief purpose of this book is to guide the power-plant operator in the selection of instruments, methods and rules that will give him proper supervision and regulation of power-plant machinery. Methods of increasing efficiency of boilers, furnaces, gas producers and steam engines are given. Special attention is given to automatic regulation.

Petroleum and Coal; the Keys to the Future.

By W. T. Thom, Jr. Princeton, Princeton Univ. Press, 1929. 223 pp., illus., maps, tables, 9 x 6 in., cloth. $2.50.

A clear, authoritative account of the principal industrial fuels, told briefly and in terms intelligible to the general reader. In an introductory chapter ancient and modern civilizations are compared, and the influence of these fuels upon national policies is discussed. The origin and occurrence of coal and oil, the coal and oil fields of the world, and the methods of discovering and working them are then described. The closing chapter discusses the size and adequacy of the remaining reserves and their bearing upon the future of civilization. The book will give those interested in public affairs a good picture of the situation, divested of details.

Polar Molecules.

By P. Debye. N. Y., Chemical Catalog Co., 1929. 172 pp., 9 x 6 in., cloth. $3.50.

The dielectric and optical properties of molecules when subjected to an external electrical field are the subject of this monograph. Dr. Debye has brought together the widely scattered literature, and offers a comprehensive review of our experimental and theoretical knowledge.

Power Resources of the World; potential and developed.

By International Executive Council. World Power Conference, London. Lond., World Power Conference, 1929. 170 pp., tables, 10 x 6 in., cloth. $4.25.

This important monograph has two purposes. It first aims to coordinate the available information on the coal resources, water power, and oil of the world, and on electric power production. Its second purpose is to indicate inequalities and omissions in the various systems for assessing power resources, and thus to further the adoption of uniform methods that will enable an accurate appraisal to be made.

The book brings together the best available estimate of our present and potential power resources. It also contains a bibliography of the power resources of the world, covering the period 1924 to 1928.

Professor Coker's PhotoElastic Apparatus.

Lond., Adam Hilger, Ltd., 1929. 28 pp., illus., 10 x 6 in., paper. Price not quoted.

This pamphlet describes a method for investigating stresses in structures for which no mathematical solutions are available, by observations, under polarized light, on models made of transparent materials, such as celluloid or glass. The method is applicable to a great variety of engineering problems.

The apparatus invented by Professor Coker is described in detail and the method of use explained.

Pyrolysis of Carbon Compounds.

By Charles D. Hurd. N. Y., Chemical Catalog Company, 1929. (Amer. Chemical Society. Monograph series). 807 pp., tables, 9 x 6 in., cloth. $12.50.

Professor Hurd has attempted to survey completely and organize rationally the voluminous, scattered literature upon the transformations produced in organic compounds through the agency of heat alone. His large monograph will be of great value to all workers in this important field, who will find here a thorough review of what is known with references to the original publications.

Seven Place Natural Trigonometrical Functions.

By Howard Chapin Ives. N. Y., John Wiley & Sons, 1929. 222 pp., tables, 7 x 4 in., fabrikoid. $2.50.

A compact set of tables which includes those most frequently wanted by surveyors and railroad engineers. The growing use of calculating machines for computations makes these tables of natural functions most welcome.

Siemens Jahrbuch, 1929.

By Siemens & Halske, & Siemens-Schuckertwerke. Berlin, V. D. I. Verlag, 1929. 644 pp., illus., port., diagrs., tables, 8 x 6 in., cloth. 12.-r. m.

The new issue of this handsome annual follows the plan of previous years, of presenting in nontechnical language accounts of important scientific and technical advances recently made by the Siemens concerns. Contributions on telegraphy, electrochemistry, steam turbines, heavy-duty switchgear and many other branches of electrical engineering are included. Of historic interest are several letters written fifty years ago by Werner von Siemens to his brothers, and papers on electric mine locomotives, Pupin coils, and automatic telephony.

Sons of Martha; a historical and biological record covering a century of American Achievement by an organization of master builders.

By Dixon Merritt. N. Y., Mason & Hangar Co., 1928. 319 pp., illus., ports., 8 x 6 in., cloth. $3.00.

A history of the well-known contracting firm, the Mason & Hanger Company, and its predecessors. The founder, Claibourne R. Mason, took his first road contract in 1819. The organization built many railroads, chiefly in the South, and participated in the construction of the Chicago Drainage Canal, the Catskill Water System, and the Port Newark Terminal. Other important work entrusted to it include the Charleston Port Terminal, the Old Hickory powder plant and the foundations of the Fort Lee Bridge.

Statistik der Elektrizitätswerke und der Elektrischen Bahnen Osterreichs. 1927.

By Elektrotechnischer Verein in Wien. Wien, Verlag des Elektrotechnischen Vereines, [1929]. 188 pp., map, 12 x 9 in., boards. 20s (Austrian).

Presents the statistics of more than 800 electric power plants and 33 electric railroads in Austria, as of the end of 1927. These are arranged both alphabetically and geographically.

Statistischer Quellen-Nachweis Für die Durchführung von Marktanalysen.

By A. Reithinger. Berlin, V. D. I. Verlag, 1929. (Wirtschaftlicher Vertrieb, heft 1). 45 pp., 9 x 6 in., paper. 3,50 r. m.

A guide to the official statistics of Germany, compiled from the point of view of those engaged in market analysis. The statistical publications of use for this purpose are indexed alphabetically under appropriate subjects, so that the user can readily ascertain what is available on any subject and where it will be found.

Taschenbuch für Fernmeldetechniker.

By Hermann W. Goetsch. 4th edition. Mün. & Ber., R. Oldenbourg, 1929. 526 pp., illus., diagrs., 7 x 5 in., cloth. 13.-r. m.

The Taschenbuch für Fernmeldetechniker is a convenient ready reference work on telegraphy, telephony and electric signaling over wires. The theoretical principles, the design and installation of the apparatus, and the operation and testing of systems is covered practically, with considerable detail. Space is given to electric pyrometers, burglar alarms, railroad and mine signals, clocks, and other recording and signalling apparatus. Printing and sound telegraphs are discussed. The book is an excellent description of German practise.

VENTILATION OF MINES; Generation of the Air Current.

By Henry Briggs. Lond., Methuen & Co., 1929. 136 pp., illus., diagrs., tables, 8 x 5 in., cloth. 7/6.

Contains the substance of a series of lectures delivered in the Royal School of Mines in 1927. Professor Briggs treats of the design and application of the ventilating machines and appliances used in modern mining practise, giving special attention to recent developments. No attempt is made to be exhaustive, but attention is given especially to those matters which are often not understood.

WALZWERKSWESEN, v. 1.

Edited by J. Puppe & G. Stauber. (Handbuch des Eisenhüttenwesens). Düsseldorf, Verlag Stahleisen; Berlin, Julius Springer, 1929. 777 pp., illus., plates, diagrs., tables, 11 x 8 in., cloth. 85.-r. m.

This is the first volume of the most exhaustive treatise on the rolling of iron and steel that has ever been published. The work has been prepared under the auspices of the German Society of Ironmasters, by a number of well-known specialists under the leadership of J. Puppe. When complete it will comprise four volumes.

The work is designed to be a complete treatise on rolling-mill practise. While special attention will be given to technical matters, economic and scientific matters will also be considered, so that the book will summarize completely our present knowledge in this field.

Volume I contains: the national and international economic importance of rolling-mills, by Drs. Reichert and Buchmann; the historical evolution of rolling, by Dr. Johannsen; the constitution and properties of malleable and rollable iron, by Drs. Oberhoffer and Esser; the constitution of metals, by Dr. Hengstenberg; testing of materials, by Dr. Moser; specifications and standards, by Dr. Schulz; cost accounting, by Dr. Jordan; operating statistics and supervision, by Drs. Jordan and Rummel; the rolling process, by Dr. Koerber; rolls, by Dr. Emicke; and roll trains, by Dr. Puppe.

Succeeding volumes will discuss the rolling of various products, heating furnaces, conveyors, cranes, and other accessories.

ZUGBILDUNGSKOSTEN, ZUGFÖRDERKOSTEN UND IHRE WECHSELBEZIEHUNGEN.

By G. Capelle, A. Baumann, and R. Feindler. Berlin, Guido Hackebeil [1929]. 142 pp., graphs, tables, 9 x 6 in., paper. 3.-r. m.

The interrelations between the cost of making up trains and the cost of running them have been carefully investigated by these authors for the German National Railroad Company. Their findings are given in full detail in this report, which analyzes the various operations involved and determine the influence of each on the total cost of operating trains and discusses the correlation between running and making up trains. The report is a valuable document on the subject.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

GRADUATE ASSISTANTSHIPS, open to graduates in electrical engineering. Positions permit half time to be devoted to the pursuit of graduate work in electrical engineering toward the degree of Master of Science. The other half time is assigned to teaching duties in the electrical engineering laboratory. Period of service is from September 20th to June 20th. Apply by letter. Salary $800. Location, Middle West. X-8383-S-R-410-C.

PROFESSOR OF ELECTRICAL ENGINEERING, to begin September 20, 1929. Must be a wide-awake, progressive man of both practical and teaching experience. Must have a degree in Electrical Engineering and in addition a Master's degree. Must be capable of carrying graduate and research work, and also willing to carry a reasonable amount of junior and senior undergraduate work in electrical engineering. Other things being equal, preference would be given to a man with some experience in transmission and distribution. Must be mathematically minded and no one will be considered who cannot qualify as a superior teacher. Important that he be of congenial disposition and have a sympathetic attitude toward students. Apply by letter. Location, Middle west. X-8384-S-R-411-C.

ENGINEER, experienced, graduate preferred, to assist in the development of intricate automatic machinery, also involving electrical control, essential to basic industry and in large and increasing use. Apply by letter. Location, Middle west. X-8551-C.

ELECTRICAL ENGINEERING GRADUATE OF UNIVERSITY, of recognized standing desired by middle west utility. Applicant should have from one to five years' experience in electrical utility work and should have superior mathematical, technical and analytical ability to properly qualify him for the wide variety of engineering studies made by company. Apply by letter. Location, Middle West. X-8396-S-R-409-C.

ELECTRICAL DRAFTSMEN, technical graduates, experienced in out-door high tension substation design preferred. Apply by letter giving complete details of education and experience and enclose recent photograph. Salaries $150-$200 a month. Location, South. X-8508.

ENGINEER, with a leaning toward economics and some electrical or mechanical engineering training. Work will be comparing actual costs against estimates, tracing cause of high costs and assisting department heads in cost reduction, etc. Apply by letter giving experience, age, earning ability and other facts which will help decide whether an interview will be mutually profitable. Location, Middle West. X-8456-C.

ELECTRICAL ENGINEERS, young, recent graduates, who had good scholastic standing and have had experience in engineering, construction, operation or the manufacture of equipment for power companies. Must be capable of doing general engineering and station design work. Apply by letter. Location, Middle west. X-8546-C.

MEN AVAILABLE

ELECTRICAL ENGINEER, over 15 years' experience in electric light and power field; several years in charge of work, desires position in charge of electrical engineering work for central station company, either with or without construction and operating duties. University graduate, with good technical knowledge and ability to handle men. B-1923.

ELECTRICAL ENGINEER, graduate, desires position with manufacturing concern, public utility, or contractor; 18 years' experience in the

electrical industry, 10 of which, up to date, connected with the largest public utility company. Design, construction, maintenance, power houses, sub-stations, distribution, handling materials, specifications, etc. Location desired, here or abroad. C-6055.

ENERGETIC ELECTRICAL ENGINEER, Cornell graduate, 30, married, now employed, wants greater opportunity, willing to start low; six years' experience with large public utility on general, power plant testing, and relay protection engineering, both field and office work. Has executive ability, highly technical, agreeable personality. Desires permanent connection with high-class public utility or manufacturing concern. Location, immaterial except South. Present salary $350. C-6096.

MAINTENANCE ENGINEER, technical education in electrical engineering, 35, married; 12 years' experience in construction of power plants and substations, maintenance, tests and one year operating a small plant. Good knowledge of equipment, cooperative ability, desires position with industrial or manufacturing organization, public utility or construction engineers. Now employed in East. Location, immaterial References, present employer. C-2021.

ELECTRICAL AND STRUCTURAL ENGINEER. Eighteen years' power plant experience with engineers, contractors, public utilities as designer, supervising engineer and consultant in domestic and Latin-American field. Specialist on high-tension transmission lines, outdoor substations. Desires position as executive in engineering or administrative work. Location, immaterial. C-5824.

ELECTRICAL ENGINEER, 22, single, 1928 graduate with degree of B. E. E. with honors; 1½ years' experience in testing. Desires position with industrial and construction company or public utility, with opportunity. C-6039.

GRADUATE ELECTRICAL ENGINEER would like to make a substantial connection with industrial firm or public utility as an engineer or assistant to Electrical Engineer or Superintendent of Operation. Two years' Westinghouse test; five years' industrial electrical engineering experience; five years electrical design, drafting and operation of power plants and substations; also familiar with transmission line calculations. B-8379.

ELECTRICAL ENGINEER, 40, married, 20 years' broad experience testing, design, construction, and supervision with well-known corporations; one year teaching, desires permanent position with responsible company on construction or operation. Location, United States, South preferred. B-1473.

SALES EXECUTIVE, a business getter, 40, with broad knowledge of production construction and sales and a record as a successful sales engineer, district manager and assistant sales manager will consider position leading to a sales or district managership in either electrical or mechanical lines. B-3065.

ELECTRICAL ENGINEER, 35, married, with twelve years' public utility operating and management experience desires public utility connection. Available on reasonable notice. C-6120.

EXECUTIVE MANAGER, electrical and mechanical. 24 years' successful experience, including teaching leading university; engineer Westinghouse; engineer, utility commission. public utility electrical and mechanical engineer and Manager last eleven years. Completely rebuilt power plant and distribution; made new rate schedules and personally handled sales of large power customers. Middle West preferred. B-7848.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER with two years of post-graduate work in physics. Desires position as research or consulting engineer. Ten years' experience in high-tension and automatic devices and some X-Ray work. Has executive and organizing ability. Desires position as designing engineer where facilities for research are available. Location, United States or abroad. B-9406.

ELECTRICAL ENGINEER, 24, single, six months general testing, two and a half years design of rural and city distribution. Desires connection in a distribution department with a future. Available on reasonable notice. Location preferred, East. C-5454.

ELECTRICAL ENGINEERING TEACHER with nine years' teaching experience desires position above the grade of instructor where an opportunity can be had of completing work for doctor's degree. Has M. S. degree and General Electric Test, as well as teaching and research experience. B-660.

CHIEF ENGINEER, Industrial Plant. Graduate of Pratt Institute, 38, married. Experienced in electrical wiring and maintenance, computing generation costs and making tests of boiler efficiencies. Desires a position offering opportunities for advancement. Prefer Connecticut or in or about New York City. C-4404.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR TRANSFER

The Board of Examiners, at its meeting held June 19, 1929, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Member

BRYANT, ROGER H., Electrical Engineer, American Steel & Wire Co., Worcester, Mass.

CHADBURN, RALPH W., Asst. Supt., Standardizing and Testing Dept., Edison Elec. Ill. Co. of Boston, Boston, Mass.

DIKE, PERCY R., Designer, Commonwealth Edison Co., Chicago, Ill.

DOUGLAS, JOHN A., Instructor, Educational Bureau, Brooklyn Edison Co., Brooklyn, N. Y.

DUDLEY, CARLTON L., Engineer, Public Service Elec. & Gas Co., Newark, N. J.

EYNON, STUART J., Meter and Instrument Engg. Dept., General Elec. Co., Lynn, Mass.

FRANKENBERRY, THOMAS H., Transformer Design Engineer, Westinghouse Elec. & Mfg Co., Sharon, Pa.

FRITZ, HARRY R., General Transmission and Protection Engineer, Southwestern Bell Telephone Co., St. Louis, Mo.

GILBERT, JOHN J., Electrical Engineer, Bell Telephone Labs., New York, N. Y.

GODDARD, MYRON C., Member of Technical Staff, Bell Telephone Labs., New York, N. Y.

HENRY RAYMOND T., Asst. Elec. Engr., Niagara Falls Power Co., Niagara Falls, N. Y.

HILL, LELAND H., Manager, Transformer Division, American Brown Boveri Elec. Corp., Camden, N. J.

HILLHOUSE, A. S., Consulting Engineer, Cleveland, Ohio.

KESSEL, HERBERT, Asst. Chief Engineer, Fairbanks Morse & Co., Indianapolis, Ind.

KRUSE, ROBERT S., Consulting Engineer, West Hartford, Conn.

LeCLAIR, TITUS G., Asst. Engr., Commonwealth Edison Co., Chicago, Ill.

LOGAN, MAURICE H., Division Substation Operator, Public Service Elec. & Gas Co., Jersey City, N. J.

MILLER, KENNETH W., Asst. Head Engr., Technical Division, Street Dept., Commonwealth Edison Co., Chicago, Ill.

NELSON, ARTHUR R., Asst. to Division Supt., Public Service Elec. & Gas Co., Trenton, N. J.

OTTEN, HARRY C., Asst. Supt. of Substations, United Electric Light and Power Co., New York, N. Y.

PENGILLY, Secretary-Treasurer, Diamond Electrical Mfg. Co., Los Angeles, Cal.

PORTER, GEORGE McC., Associate Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

PUGH, EMERSON, Electrical Engineer, Western Electric Co., Chicago, Ill.

RICHARDSON, A. N., Operating Supt., Illinois Northern Utilities Co., Dixon, Ill.

ROBERTS, L. S., General Exchange Supervisor, Southwestern Bell Telephone Co., St. Louis, Mo.

SALTER, ERNEST H., Engineer in charge, Cable Research, Electrical Testing Labs., New York, N. Y.

SUYDAM. C. H., Acting Chief Engineer, Federal Telegraph Co., Palo Alta, Calif.

THOMAS, EVERETT E., Application Engineer, General Electric Co., Schenectady, N. Y.

THOMAS, BENJAMIN F., Consulting Engineer, Exchange Building, St. Louis, Mo.

WEIR, PAUL L., Designer of Transmission Lines and Structures, Byllesby Engg. & Mgt. Corp., Pittsburgh, Pa.

WILDES, KARL L., Asst. Prof. of Elec. Engg., Mass. Inst. of Technology, Cambridge, Mass.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before July 31, 1929.

Beardow, G. M., Bell Telephone Laboratories, Inc., New York, N. Y.

Becker, L. W., Lieut., (Member), *U. S. S. Mississippi*, San Francisco, Calif.

Berman, M. E., General Electric Co., Detroit, Mich.

Bricker, E. E., Pacific Tel. & Tel. Co., San Francisco, Calif.

Broecker, A. F., Kimberly-Clark Corp., Neenah, Wis.

Burnett, J., (Member), Pacific Electric Clock Co., Inc., Berkeley, Calif.

Conway, J. O., Electrical Research Products, New York, N. Y.

Crump, T. W., International Business Machine Corp., Charlotte, N. C.

D'Hyevre, A., Detroit Edison Co., Detroit, Mich.

Dickins, R. C., Canadian National Telegraphs, Sioux Lookout, Ont., Can.

Dixon, L., New York Central Railroad Power Station, New York, N. Y.

Duphorne, H. M., Southwestern Bell Telephone Co., Oklahoma City, Okla.

Elsdon-Dew, A. E., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Fitzgerald, J. D., General Electric Co., Chicago, Ill.

Foster, J. E., Long Island Lighting Co., Roslyn Heights, N. Y.

Frankhouser, D. C., Bennington Electric Co., Curwensville, Pa.

Frenz, H. J., Victor Talking Machine Co., Camden, N. J.
Fullerton, D. P., Jr., Electrical Research Products, Inc., New York, N. Y.
Gray, S. K., Dayton Power & Light Co., Dayton, Ohio
Gray, W. T., Jr., Northwestern University, Evanston, Ill.
Hecht, W. C., Bell Telephone Co. of Penna., Pittsburgh, Pa.
Heim, E. F., (Member), 1800 "E" St., N. W., Washington, D. C.
Horspool, G., Calgary Power Co., Ltd., Seebe, Alberta, Can.
Jacobson, M., Jordan Marsh Co., Boston, Mass.
Keen, A. H., General Electric Co., Dallas, Tex.
Keiper, R. C., Bethlehem Steel Co., Allentown, Pa.
Kelter, J. C., Harry Alexander, Inc., New York, N. Y.
Labunski, C. M., Detroit Edison Co., Detroit, Mich.
La Cauza, F. E., Harvard University, Cambridge, Mass.
Lane, A. M., Pacific States Electric Co., San Francisco, Calif.
Lawrence, R. E., J. G. White Engg. Corp., Boling, Tex.
Legg, B. B., (Member), Columbia Engineering & Management Corp., Columbus, Ohio
Lowe, H. D., Electrical Research Products, Inc., Hollywood, Calif.
Ludwell, F. R., Pacific Electric Mfg. Co., San Francisco, Calif.
Manning, R. P., Westchester Lighting Co., Mount Vernon, N. Y.
McCarthy, J. J., Cleveland Rilway Co., Cleveland, Ohio
McNulta, L. F., New York Telephone Co., New Rochelle, N. Y.
Meeker, H. A., Meeker Electric Co., Williston Park, N. Y.
Mikelberg, S., Stone & Webster Corp., Boston, Mass.
Miller, D. S., 225 Greenfield St., Hartford, Conn.
Mullen, J. T., Southwestern Bell Telephone Co., Kansas City, Mo.
Powell, E. M., Westinghouse Elec. & Mfg. Co., Wilkes-Barre, Pa.
Raine, R. W., American Electric Co., Miami, Fla.
Reed, G. L., Western New York Gas & Electric Corp., Lancaster, N. Y.
Schlossberg, V. E., Inland Steel Co., East Chicago, Ind.
Schneider, R. G., Harry D. Payne, Houston, Tex.
Shortt, J. F., Corporation of Penticton, Penticton, B. C., Can.
Stephenson, D. C., Northern Light & Power Co., Indian Head, Sask., Can.
Sweet, D. M., Public Service Co. of No. Illinois, Chicago, Ill.
Vogel, O. S., Georgia Power Co., Atlanta, Ga.
Watkins, N., U. S. Government, Wright Field, Dayton, Ohio
Watts, W., Lehigh Portland Cement Co., Oglesby, Ill.
Weber, G. A., City Hall, Palo Alto, Calif.
Welter, G., American Brown Boveri Electric Corp. Camden, N. J.
Wheeler, H. J., General Electric Co., Schenectady, N. Y.
Williams, W. K., Dallas Power & Light Co., Dallas, Tex.
Wray, T., Simplex Wire & Cable Co., Cleveland, Ohio
Total 55.

Foreign

Brown, A. F., c/o Anglo Persion Oil Co., Abadan, Persian Gulf.
Buck, E. C., (Fellow), British Engineering Manufacturers' Alliance Ltd., Port of Spain, Trinidad, B. W. I.
Deane, H. E., Electrical Contractor, P. O. Box 273, Bridgetown, Barbados, B. W. I.
Dewis, J. H., Rustor & Hornsby Ltd., Sydney, Australia
Faber, C. W., Rio de Janeiro Tramway Light & Power Co., Rio de Janeiro, Brazil, So. America
Ganguli, A. K., East Indian Railway Electric Power Sta., Cawnpore, India
Gopinath, S. K., M. & S. M. Railway Workshops, Perambur, Madras, India
Harvey, A. H., Energia Electrica de Cartagena, Cartagena, Colombia, So. America
Kirkpatrick, H. J., Rio de Janeiro Tramway Light & Power Co., Rio de Janeiro, Brazil, So. America
Lambert, S., Porcelainerie de Lesquin, Paris, France
Rao, K. N., (Member), Municipal Electrical Engineer, Hindupur, Anantapur District, So. India
Rawal, T. R., Anglo Persian Oil Co., Ltd., Masjid-I-Sulaiman, S. W. Persia
Vanden Meersche, A. J., University of Ghent, Ghent, Belgium
Webb, T. F., Standard-Waygood, Ltd., Clyde, N. S. W., Australia
Total 14.

STUDENTS ENROLLED

Ackerman, Carl D., Case School of Applied Science
Ainsworth, Harold, University of Alberta
Alexander, John J., University of North Carolina
Allen, Thomas W., North Dakota Agricultural College
Anderson, Albert W., North Dakota Agricultural College
Andujar, Manuel, Jr., Pennsylvania State College
Avary, Stephens, A., Emory University
Azarian, Levon, Robert College
Bagg, Richard F., Rensselaer Polytechnic Institute
Barnhouse, Thomas D., Ohio University
Beers, Randal H., Stevens Institute of Technology
Bloodworth, Thomas H., Georgia School of Technology
Bosely, William S., Jr., West Virginia University
Brady, Elisha E., University of Oklahoma
Bridges, Josiah A., Stanford University
Brown, William B., Newark Coll. of Engineering
Buchanan, Lloyd C., State College of Washington
Cain, Doyle E., University of Texas
Calcagni, Levio, University of Vermont
Caldwell, Colonel L., State College of Washington
Carter, Bruce H., Ohio State University
Carter, Hubert C., Emory University
Castano, Francisco, Georgia School of Technology
Carpenter, Chauncey L., Case School of Applied Science
Center, Clare E., Worcester Polytechnic Institute
Chatham, Arthur A., Case School of Applied Science
Clark, Ralph L., Michigan State College
Clays, Ernest M., University of Nevada
Conway, Clifford C., University of Illinois
Cook, Eugene G., Texas A. & M. College
Cooper, Marvin L., University of Missouri
Dalton, Harold R., Brooklyn Polytechnic Institute
Davidson, John W., Worcester Polytechnic Inst.
Dean, John E., Michigan State College
DeVries, Lawrence H., Michigan State College
DiToro, Michael J., Brooklyn Polytechnic Institute
Duckwitz, William M., University of Michigan
Durant, Ronald J., Georgia School of Technology
Ellingson, Edward V., North Dakota Agricultural College
Elliott, Howard E., Ohio State University
Elliott, William E., Georgia School of Technology
Evans, L. H., Jr., Texas A. & M. College
Ewing, Chester A., Massachusetts Institute of Technology
Fenton, Earl L., North Dakota Agricultural College
Fenwick, Arden B., Purdue University
Finkelstein, Saul, University of Illinois
Fisher, Cameron E., University of Illinois
Fleming, Spain T., University of Tennessee
Freeland, Frank, Oregon Institute of Technology
Gardner, Roland H., Case School of Applied Science
Garlock, Robert G., University of Wisconsin
Gartrell, Everett A., Worcester Polytechnic Institute
Gawlowicz, Boleslaw S., Worcester Polytechnic Institute
Globensky, Paul J., State College of Washington
Goodnow, Albert M., Worcester Polytechnic Institute
Graham, Howard E., University of Illinois
Greco, Carmelo S., Worcester Polytechnic Institute
Green, Francis A., Case School of Applied Science
Hall, Gilbert O., Michigan State College
Hango, John R., University of Alberta
Harper, Edwin R., Worcester Polytechnic Institute
Hay, Edward C., University of British Columbia
Hedgpeth, Thaddeus V., University of North Carolina
Heinzen, Harry R., South Dakota State College
Hillegas, John W., Georgia School of Technology
Hinzdel, J. James, Case School of Applied Science
Holmes, Clarence L., State College of Washington
Horton, Holbrook L., Worcester Polytechnic Institute
Howard, Arthur J., Northeastern University
Hunt, Melvin W., North Dakota Agricultural College
Kahale, Noureddeen, Robert College
Keeney, Dwight E., Worcester Polytechnic Institute
Keleshian, Hagop, Robert College
Kelley, Richard, Northeastern University
Kelly, Joseph J., Northeastern University
Kirkhope, Peter G., Case School of Applied Science
Klingenstein, John, Lewis Institute
Kouyoumdjian, Kerop, Robert College
Kouyoumdjian, Vahram, Robert College
Langaunet, Joseph C., North Dakota Agricultural College
Livie, Jack, State College of Washington
Locke, William W. Jr., Worcester Polytechnic Institute
Low, Charlie L., University of Kansas
MacGregor, Donald A., Syracuse University
MacGregor, James G., University of Alberta
Marose, LeRoy W., University of Illinois
McCown, Robert L., Texas A. & M. College
McLoughlin, James E., Worcester Polytechnic Institute
Meldahl, Lawrence A., North Dakota Agricultural College
Merrill, Arthur E., University of Vermont
Miridjanian, Nourhan, Robert College
Moore, Samuel L., Georgia School of Technology
Mordaunt, Walter G., Engineering School of Milwaukee
Morrical, Keron C., University of Illinois
Morton, Homer A., Montana State College
Nagrath, Gian C., University of Illinois
Nakashidze, Prince Dimitri M., Robert College
Neilson, Howard, Texas A. & M. College
Nelson, Edwin K., University of Illinois
Newcomb, Lamar A., Georgia School of Technology
Norris, Dale R., Michigan State College
Olson, Elof, University of Alberta
Olson, Roger E., North Dakota Agricultural College
Orphanides, Christ L., Worcester Polytchnic Institute
Owen, Lucien E., Alabama Polytechnic Institute
Parsons, Marshall F., Michigan State College
Pearce, Heyward, University of Michigan
Pederson, Marcus, North Dakota Agricultural College
Phanuef, Edgar A., Worcester Polytechnic Institute
Puddington, Roy W., Worcester Polytechnic Institute
Ramsay, Joseph D., University of Tennessee
Rand, Irvin J., Case School of Applied Science
Reed, Harold E., Northeastern University
Rice, William B., University of Illinois
Rickover, Hyman G., Columbia University

Roggenburk, Robert W., Case School of Applied Science
Rowe, Hobart E., Michigan State College
Russ, Chester A., Case School of Applied Science
Schaffer, Philip, Rhode Island State College
Schlachter, Benjamin, College of the City of New York
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Schnabel, Arnold O., Purdue University
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Fuse and Disconnecting Switches.—Bulletin 503, 28 pp. Describes Matthews fuswitches and disconnecting switches housed in cypress wood. Bulletin 504, 32 pp. describes similar equipment, but of open type. Both bulletins are profusely illustrated, showing the latest improvements in the complete line. W. N. Matthews Corporation, St. Louis, Mo.

Circuit Breakers.—Bulletin 600, 20 pp. Describes type "O" oil switches and circuit breakers in capacities from 200 to 2000 amperes, from 2500 to 15,000 volts and with interrupting capacities from 20,000 to 40,000 kv-a. They are made as two-pole and three-pole devices, automatic and non-automatic, single and double throw, for switchboard, wall and cell mounting; also for hand operation, normal and remote control and electrical operation. All necessary styles of trips and all the usual auxiliaries required in oil switch operation are available. Roller-Smith Company, 233 Broadway, New York.

Traffic Control.—Bulletin "Miller Traffic Control," 18 pp. Describes the Miller "Trafilator," a new system for which is claimed all of the benefits of the arbitrarily time traffic systems, and in addition halts traffic only when necessary. The "trafilator" is composed of three units, the detector, a combination relay and rectifier, and a condenser. The detector is a vehicle detecting device which is buried in the street so that the top does not extend above street level. It operates on the magnetics Wheatstone Bridge principle also employed in the Miller Induction System of Train Control now in successful operation on railroads. Trafilators are unlimited in their applications; they do not supplant but work in conjunction with, and may be added to, any standard signal system. They are universally adapted to any signaling condition, and their use will prevent long, unnecessary stops and give ultimate street capacity consistent with safety at any intersection regardless of whether it is an isolated intersection or a part of an interconnected system. The Miller Train Control Corporation, Staunton, Va.

NOTES OF THE INDUSTRY

The Copperweld Steel Company, Glassport, Pa., has formed a southeastern district comprised of Georgia, Alabama, Tennessee, Florida, Mississippi, and part of Louisiana, with P. A. Terrell in charge as district manager. The office of this district is located in the American Traders Bank Building, Birmingham, Alabama.

Delta-Star Buys Foundry.—H. W. Young, president of the Delta-Star Electric Company, Chicago, announces the purchase of the buildings and equipment of the Howard Foundry and Pattern Shops with which will be combined the present Delta-Star foundry. This addition to Delta-Star's foundry facilities will insure adequate production of copper, aluminum, manganese bronze and brass castings.

Century Electric Acquires Roth Bros.—The Century Electric Company has purchased Roth Brothers & Company, Chicago, Ill., manufacturers of motors and generators and motor generator sets. While Roth Brothers & Company will be operated as a division of the Century Electric Company, some of its products will now be manufactured in the Century Electric Company's plant in St. Louis. The acquisition of Roth Brothers & Company will result in broadening the Century Company's already influential position in the electrical apparatus manufacturing field, by supplementing its line of polyphase induction industrial power motors and its line of single-phase motors in which it has pioneered, and which have contributed to making possible the rapid development and popularity of the household refrigerator and many other widely used devices.

Manufacturers Join NEMA.—Fifteen manufacturing companies have joined the National Electrical Manufacturers Association and are affiliated in eleven sections according to an announcement from NEMA Headquarters. The manufacturers and their section affiliations are as follows:

Wire and Cable Section: Gavitt Mfg. Co., Globe Insulated Wire Co.; Carbon Arc Lamp Section: A. S. Aloe Co., Hibner Electric Co.; Switchgear Section: Line Material Co.; Molded Insulation Section: Mack Molding Co., The Recto Mfg. Co., Union Insulating Co.; Lamp Receptacle and Socket Section: John I. Paulding, Inc.; Electric Measuring Instrument Section: Standard Transformer Co.; Laminated Phenolic Products Section: Synthane Corp.; Rigid Conduit Section: Walker Brothers; Carbon Section: Pure Carbon Co.; Electric Range and Heating Section: Automatic Electric Heater Co.; High Voltage Insulator Section: Porcelain Insulator Corporation.

Colleges Represented in the General Electric Company.—More than 4400 college graduates, representing approximately 215 American universities, colleges and technical schools, are in the employ of the General Electric Company. The figures include only those who completed a course for a degree.

In training, the classification includes: Electrical engineering, 3278; mechanical engineering, 529; civil engineering, 71; chemical and ceramic, 132; metallurgical, mining and physics, 53; aeronautical, radio and marine, 12; general engineering, 142; scientific, 98; liberal arts, 272; business administration, law, etc., 178. The term "general engineering" includes administrative, agricultural, architectural and industrial engineering, and U. S. Naval Academy engineering.

By departments, the college graduates are classified as follows: District offices, 1062; general office commercial departments, 349; general office commercial engineering departments, 197; engineering and drafting, apparatus works, 1167; manufacturing, apparatus works, 520; general engineering and Schenectady laboratories, 200; general manufacturing, 27; general accounting, 139; other general administrative departments, 66; merchandise department, 43; electric refrigeration department, 34; International General Electric Company, 179; incandescent lamp department, 333; and first year test men at Schenectady and elsewhere, 449.